N O T I C E

THIS DOCUMENT HAS BEEN REPRODUCED FROM MICROFICHE. ALTHOUGH IT IS RECOGNIZED THAT CERTAIN PORTIONS ARE ILLEGIBLE, IT IS BEING RELEASED IN THE INTEREST OF MAKING AVAILABLE AS MUCH INFORMATION AS POSSIBLE

9450-670

DOE/JPL 955273-1

DISTRIBUTION CATEGORY UC-63

(NASA-CR-169043) EFFECTS OFF SYSTEM FACTORS ON THE ECONOMICS OF AND DEMAND FOR SMALL SOLAR THERMAL POWER SYSTEMS Final Report, Dec. 1978 - Mar. 1980 (General Electric Co.) 198 p HC A09/MF A01 CSCL 10A G3/44

N82-26800

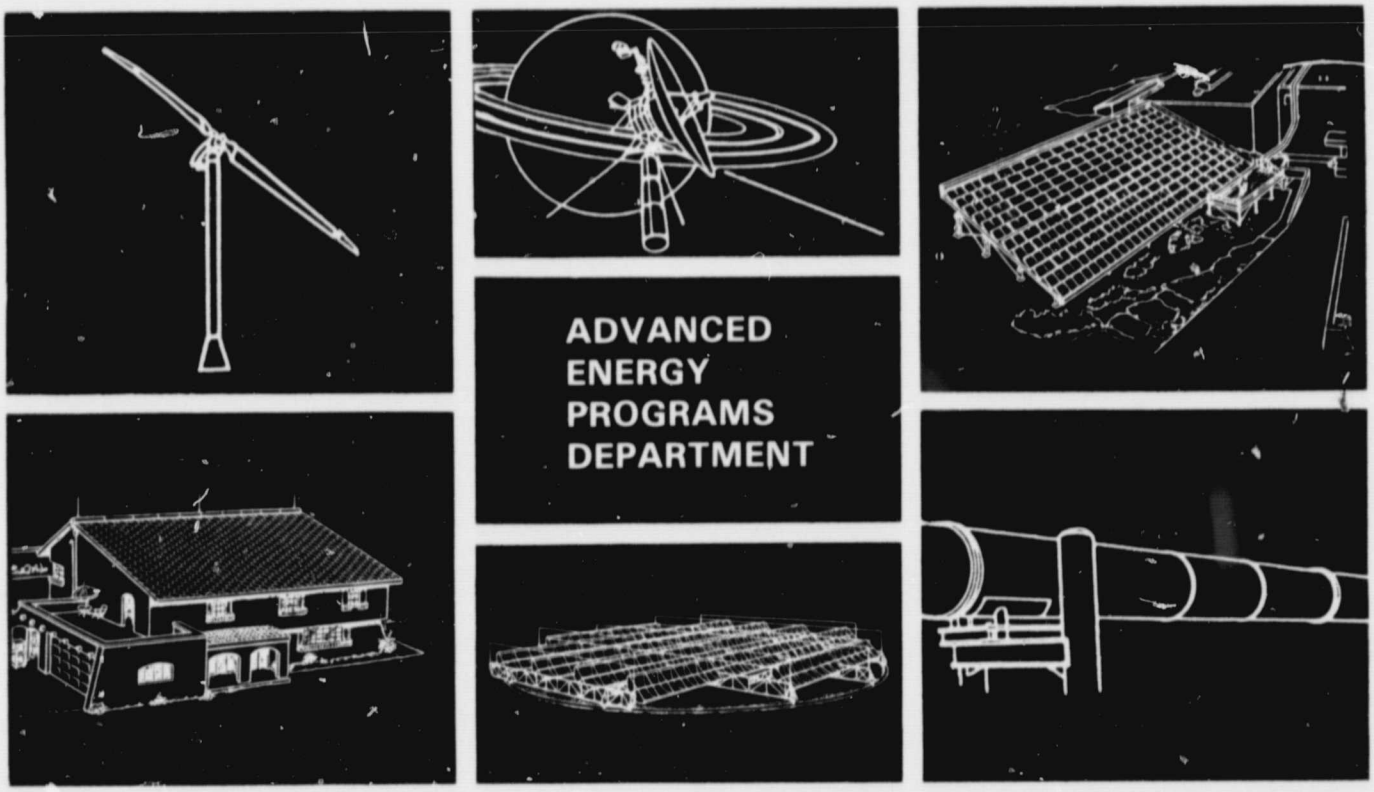
Unclas 28151

EFFECTS OF SYSTEM FACTORS ON THE ECONOMICS OF AND DEMAND FOR SMALL SOLAR THERMAL POWER SYSTEMS

JUN 1982 RECEIVED NASA STI FACILITY ACCESS DEPT.

PREPARED UNDER JPL CONTRACT 955273

REPORT DATE: SEPTEMBER, 1981



ENERGY SYSTEMS AND TECHNOLOGY DIVISION

GENERAL ELECTRIC

REPORT NO. 955273-1
SEPTEMBER, 1981

EFFECTS OF SYSTEM FACTORS ON THE ECONOMICS OF AND DEMAND FOR SMALL SOLAR THERMAL POWER SYSTEMS

FINAL REPORT

CUSTOMER: JET PROPULSION LABORATORY
CONTRACT: 955273
STUDY PERIOD: DECEMBER 1978 THROUGH MARCH 1980

ADVANCED ENERGY PROGRAMS DEPARTMENT

GENERAL ELECTRIC
ENERGY SYSTEMS AND TECHNOLOGY DIVISION
P.O. BOX 8661, PHILADELPHIA, PA. 19101

FOREWORD

This report presents the results of a study on the Effects of System Factors on the Economics of and Demand for Small Solar Thermal Power Systems. The Program was performed under Contract No. 955273 for Jet Propulsion Laboratory of the California Institute of Technology under the guidance of Dr. Richard B. Davis.

Study goals were to estimate market penetration as a function of time, SPS performance factors, and market/economic considerations and to formulate commercialization strategies. A market analysis task included personal interviews by GE personnel and supplemental mail surveys to acquire statistical data and to identify and measure attitudes, reactions and intentions of prospective SPS users. Interviews encompassed three ownership classes of electric utilities and industrial firms in the top SIC codes for energy consumption. A market demand model was developed which utilized the data base developed by personal interviews and surveys, and projected energy price and consumption data to perform sensitivity analyses and estimate potential market for SPS. Commercialization strategies were formulated on the basis of the market and penetration sensitivity analyses performed.

The study was conducted by the Advanced Energy Department of the General Electric Company Space Division. Mr. Hugh C. Goff served as Program Manager and prepared this report with contribution from Robert L. McCarthy, Phillip A. Straus, Charles Dorsa, and Chris Durgin.

The following organizations participated in this study:

Organization	Contribution
General Electric Company Advanced Energy Department - Space Division	Overall Responsibilities
Market Analysis and Research Operations Corporate Consulting Services	Market Survey Design
*Electric Utility Sales Division	Personal Interviews with Electric Utilities
*Industrial Sales Division	Personal Interviews with Industrial Firms
Valley Forge Information Services	Professional Telephone Interviewing

* Non-funded support

TABLE OF CONTENTS

	Page No.
SECTION 1 - SUMMARY AND CONCLUSIONS	1-1
1.1 Summary	1-1
1.2 Conclusions	1-2
SECTION 2 - MARKET ANALYSIS	2-1
2.1 Introduction	2-1
2.2 Small Solar Thermal Power System Configuration	2-1
2.3 Study Approach	2-9
2.3.1 Identification of Potential Users	2-10
2.3.2 Survey Format	2-15
2.3.3 The Sample	2-17
2.4 Study Results	2-22
2.4.1 Industrial Firms	2-24
2.4.2 Electric Utilities	2-40
2.4.3 Engineering Design Firms	2-53
2.5 Issues and Trends	2-61
2.5.1 Issues	2-61
2.5.2 Key Factors	2-63
SECTION 3 - SOLAR THERMAL POWER SYSTEMS DEMAND MODEL	3-1
3.1 SPS Demand Model Results	3-6
3.2 Conclusions - Demand Model	3-14
3.3 Sample Demand Model Runs	3-16
SECTION 4 - COMMERCIALIZATION STRATEGIES	4-1
4.1 Introduction and Summary	4-1
4.2 Government Policies and Incentives	4-3
4.2.1 Demonstration Programs	4-6
4.2.2 Solar and Investment Tax Credits	4-7
4.2.3 Depreciation Schedules	4-9
4.2.4 Subsidies and Low Interest Loans	4-10
4.2.5 Warranties	4-12
4.2.6 International Policies	4-13
4.3 Industrial Involvement	4-14
4.3.1 Product Introduction	4-14
4.3.2 Electric Utilities & Industrial Cogeneration Opportunities	4-19

TABLE OF CONTENTS

	Page No.
APPENDIX A - INDUSTRIAL IN-PLANT ELECTRICAL GENERATION	A-1
APPENDIX B - MATERIAL USED FOR PERSONAL INTERVIEWS AND MAIL SURVEY	
B-1 Questionnaires for Use in Conducting Personal Interviews and Mail Surveys with Electrical Utility Firms	B-1-1
B-2 Questionnaires for Use in Personal Interviews and Mail Surveys Conducted With Industrial Firms	B-2-1
B-3 Questionnaries Used in Survey of Design Engineering Firms	B-3-1
APPENDIX C - SPS MARKET DEMAND COMPUTER PROGRAM	C-1
APPENDIX D - BIBLOGRAPHY	D-1

LIST OF FIGURES

Figure No.		Page No.
2-1	Concentrating Solar Collector and Electric/Thermal	2-3
2-2	Typical Solar Plant	2-3
2-3	Typical Solar Power System	2-3
2-4	Typical Engine Distributed Generation (Engine at Collector Focal Point)	2-4
2-5	Typical Collector Details (Central Generation)	2-4
2-6	System Schematic Central Generation	2-5
2-7	1 MW Central Generation Power Module	2-6
2-8	Primary Reason for In-Plant Generation	2-25
2-9	Major Benefits Received by Industrial Firms	2-33
2-10	Major Drawbacks Perceived by Industrial Firms	2-33
2-11	Major Reasons for Negative SPS Opinion in 1990-Time Frame by Industrial Firms	2-35
2-12	Industrial Land Cost Cumulative Distribution	2-36
2-13	Industrial Land Costs Mean and Median by SIC	2-36
2-14	Industrial Return on Investment Cumulative Distribution	2-38
2-15	Distribution of Industrial Consumption by Solar Region	2-39
2-16	Average Daily Direct Insolation (kWh/M^2) by State	2-39
2-17	Effect of Land Cost and Insolation Level on Industrial Cost of Energy From Solar Power Systems	2-40
2-18	Major Benefits Perceived by Utilities	2-42
2-19	Major Drawbacks Perceived by Utilities	2-42
2-20	SPS Factors, Relative Importance to Industrial and Electric Utility Firms	2-48

LIST OF FIGURES

Figure No.		Page No.
2-21	Utility and Industrial Land Cost Cumulative Distribution	2-50
2-22	Fixed Charge Rate Distribution Investor-Owned Utilities	2-52
2-23	Distribution of Utility Capacity by Solar Region	2-54
2-24	Effect of Land Cost and Insolation Level On Utility Cost of Energy From Solar Power System	2-55
3-1	SPS Demand Model	3-2
3-2	Projected SPS Market at $1500/KW (1980 $)	3-7
3-3	SPS Market in Year 1990 Versus System Cost	3-8
3-4	SPS Market in Non-Investor Utilities	3-10
3-5	Effect of Energy Price Escalation on SPS Market	3-11
3-6	SPS Industrial Market Electricity Only	3-12
3-7	SPS Industrial Market Electricity Only	3-13
3-8	SPS Market Range for Industrial Cogeneration	3-15

LIST OF TABLES

Table No.		Page No.
2-1	1990 Solar Power System Cost Projections	2-8
2-2	1990 Solar Power System Cost Projections	2-8
2-3	Industrial Electrical Consumption and Generation by SIC Group	2-12
2-4	States Grouped by Average Daily Direct Insolation Levels	2-13
2-5	Number of Utilities by Selected Ownership Class in Each Solar Region	2-14
2-6	Number of Industrial Electric Customers by Solar Region	2-14
2-7	Utility Sample	2-19
2-8	Industrial Generators	2-20
2-9	Sample Cell Sizes	2-21
2-10	Cell Size	2-23
2-11	Average Industrial Responses on Electrical Requirements	2-25
2-12	Conversion to Other Fuel Sources	2-26
2-13	SPS Consideration as Industrial Power Generation Option in 1990	2-27
2-14	List of Possible Influencing Factors	2-28
2-15	Industrial Ranking of Influencing Factors	2-30
2-16	SPS Purchase Consideration by SIC Codes	2-32
2-17	Range of Land Costs	2-37
2-18	System Factors	2-43
2-19	Utiluty SPS Purchase Consideration in 1990-Time Frame	2-46
2-20	SPS Utility Purchase Considerations by State	2-47
2-21	Utility Investment Criteria	2-52

LIST OF TABLES

Table No.		Page No.
2-22	Comparison of Mean Survey Results and Effect on Energy Cost	2-55
2-23	Important SPS Characteristics Identified by Design/Engineering Firms	2-56
2-24	SPS Drawbacks Perceived by Design Firms	2-57
2-25	Potential SPS Application Identified by Design Firms	2-58
2-26	Design Firms' Views on Central vs Distributed Generation	2-59
2-27	International Market Characteristics Affecting SPS Applications	2-60
2-28	Design Firms General Comments on SPS	2-60
3-1	Demand Model Classifications	3-5
4-1	Government Incentives Under Consideration	4-6
4-2	Common Commercialization Elements	4-16
4-3	Significant Factors in Investment Decision for Entering Production and Sales Business	4-18

SECTION 1

SUMMARY AND CONCLUSIONS

The study goals are to estimate market penetration rates for SPS as a function of time, performance factors and market/economic considerations, and to recommend strategies for accelerating the market penetration rate for promising near-term applications. Three major tasks comprised this study; market analysis, market penetration sensitivity analysis, and commercialization strategy formulation.

1.1 SUMMARY

A nationwide study was conducted among (1) three major classes of utility ownership, i.e., investor-owned utilities, rural electric cooperatives, and municipal systems; (2) the top eight energy consuming classifications of industrial firms, and (3) selected design engineering firms. Types of industrials contacted in the study included chemicals, paper, food, transportation equipment, textiles, stone, clay, glass, petroleum refining, and others. Firms in all fifty states were included in the study sample. The selection of industrial firms included an equal number of firms with and without in-plant generation equipment to help remove bias caused by this variable. Similarly, the electric utility firms contacted included both firms which generated all or part of their power requirements as well as non-generators which function only as distributors of electric power.

Over 240 industrial, 200 electric utility and 70 design engineering firms were contacted. Although some firms declined to participate in the study for a variety of reasons, the overall response rate was over 60%.

All survey participants were given an SPS information package, which described several system configuration options and the various technologies involved. System cost and performance estimates were presented for the early 1990's time period.

Data were acquired from utility and industrial firms on land cost, land availability, financial criteria for investments, plans for dealing with future energy requirements, current and future energy consumption levels, and other factors which will impact the market acceptance of the SPS.

Some of the major factors influencing SPS purchase considerations in the 1990-time frame by these firms were also determined and ranked in importance. The SPS ability to meet these influencing factors was assessed and ranked.

Interview and survey results consistently showed that the most influential factors with both utility and industrial firms are those of a financial nature, i.e., of a non-technical nature.

Fifty-six percent of the industrial firms participating in the study indicated a positive interest in considering the SPS as a power plant option in the 1990-time frame. These positive responses came from fourteen SIC codes and were located in twenty-six states spread throughout the US. Similarly, sixty-nine out of one hundred twenty-seven electric utilities (53.5%) expressed positive interest. These utilities are located in thirty-seven states.

1.2 CONCLUSIONS

The major conclusions of this study are as follows:

1. Even with the challenging cost goals presented in the information package, system economics was still the major barrier to acceptance. SPS capital cost (and the associated cost of delivered energy) was the single most limiting factor affecting SPS acceptance in the

industrial sector. However, land requirements were mentioned as a singificant system drawback by 58% of the industrial respondents. Industrial land suitable for SPS instalaltion is much less available and, on the average, about three times as costly as suitable utility land.

2. The absolute size of the investment required was a major deterrent in the industrial sector. The utility respondents expressed concern about the size of the investment for the system capacity factor (specified at 40 percent).

3. Electric utilities typically evaluate long-term investments, such as generation equipment. Their investments can be characterized as very low risk as compared to industrial investments. These factors provide a much longer planning horizon for the utility, and a significantly lower required return on investment, or "hurdle rate", for project acceptance.

4. The trend toward more generation by rural electric cooperatives and municipal systems, coupled with lower priced land and favorable tax status gives these two classes of utilities a higher market potential for SPS than investor owned utilities and industrials, in the near-term.

5. Multiple, geographically dispersed SPS demonstration sites within the industrial and utility sectors are necessary to prove and demonstrate system performance and reliability and establish operations and maintenance requirements for prospective users. These SPS demonstrations should involve firms which are acknowledged by the sector as leaders in technological innovation.

6. Some of the industrial firms, and transmission/distribution utility firms stated that they had never generated power, and had no plans to do so in the future. Thus, even though over 50 percent of the industrial and utility firms stated they would consider purchase of the SPS as a power plant option, there is a segment of the market which would probably not be considered as viable potential customers for these systems.

7. Significant national penetration will require competitive energy costs for systems operating in moderate regions of solar energy availability (3.6 - 4.0 kWh/m^2/day average direct insolation). However, substantial markets for early SPS penetration do exist in the high insolation areas, most notably California.

8. Many of the large utility firms stated they would not consider systems whose capacity was less than 100-200 MW. Although the SPS is modular in nature, suitable land areas for such large systems may prove to be a significant barrier to market penetration in the utility sector.

SECTION 2

MARKET ANALYSIS

2.1 INTRODUCTION

In order to provide a pool of data to assess the potential market for Small Solar Power Thermal Systems (SPS), a nationwide market study was conducted. While a review of the literature indicated the availability of limited data, none of the sources examined had a broad enough scope for the purposes of this study. Over five hundred firms comprised of electric utilities, industrial companies, and engineering designers were contacted.

As a prelude to contacts, an explanatory brochure was prepared and a questionnaire developed. A combination of direct contacts by General Electric field sales engineers, telephone calls, and mail inquiries were made. An overall response rate of sixty percent was achieved. Data from these responses were analyzed and major conclusions summarized.

2.2 SMALL SOLAR THERMAL POWER SYSTEM CONFIGURATION

For the purpose of conducting the market analysis task, it was necessary to convey basic information about the SPS to a crosssection of persons, many of whom were not familiar with solar thermal systems. In order to avoid providing a great deal of unneeded technical information, only basic system characteristics were provided, commensurate with the questionaire. The responses were not intended for a technical evaluation of various system concepts, but rather the development of data for the market analysis.

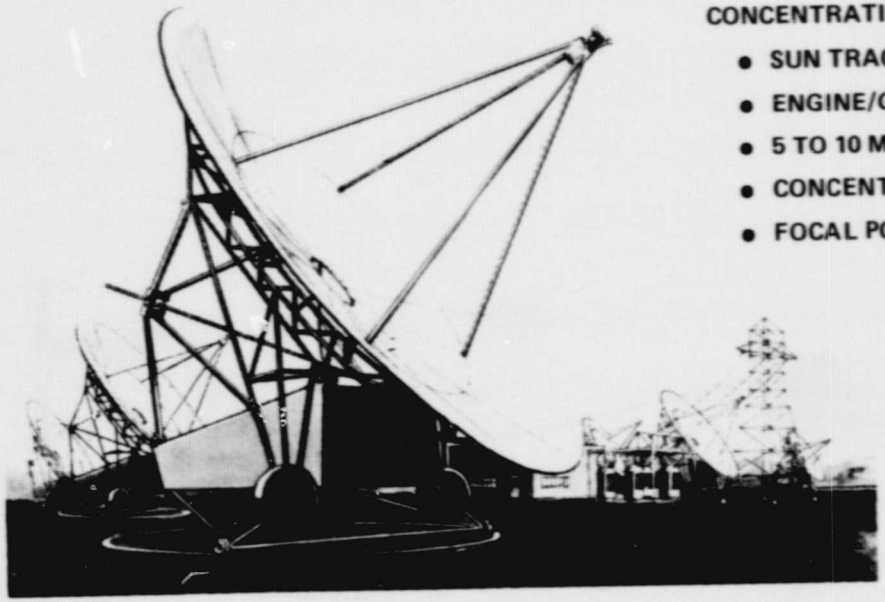
In order to acquaint the mail survey participants with the basic system concepts, Figures 2-1, 2-2, and 2-3 were provided. Sufficient information was also furnished relative to operating characteristics, electric and thermal energy output, power conversion, land area requirements and other pertinent facts to permit the respondent to make value judgements on SPS applications. Additional information was provided to GE field sales engineers conducting personal interviews. This information included configuration and operational details as shown in Figures 2-4 through 2-7, thereby allowing a more in-depth explanation of the systems.

Two basic system configurations -- electric only and electric plus thermal -- were presented to the participants. The following caveats apply:

- Thermal energy is used to produce electricity by the two system concepts being evaluated:

 - SYSTEM A OPTION - (Distributed collection distributed generation)
 Parabolic dish solar collectors concentrate sunlight on a heat engine at the collector's focal point. Figure 2-4 shows the heat receiver, which utilizes sodium as a heat transfer medium and operates at 750°C (1,382°F). The power conversion unit consists of a reciprocating Stirling cycle heat engine with gear box and alternator to produce electricity.

 - SYSTEM B OPTION - (Distributed collection central generation)
 Parabolic dish solar collectors concentrate sunlight on a heat receiver mounted at the collector's focal point as shown in Figure 2-5. At peak insolation level of 1 kW/m^2, each 7-meter solar collector can provide:



CONCENTRATING SOLAR COLLECTOR

- SUN TRACKING, AZIMUTH AND ELEVATION
- ENGINE/GENERATOR OR FLUID HEATER AT FOCAL POINT
- 5 TO 10 METERS (16 TO 33 FT) DIAMETER
- CONCENTRATION RATIOS 200 TO 2000:1
- FOCAL POINT TEMPERATURES 750° TO 2000°F

Figure 2-1. Concentrating Solar Collector and Electric/Thermal

ORIGINAL PAGE IS
OF POOR QUALITY



Figure 2-2. Typical Solar Plant



Figure 2-3. Typical Solar Power System

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

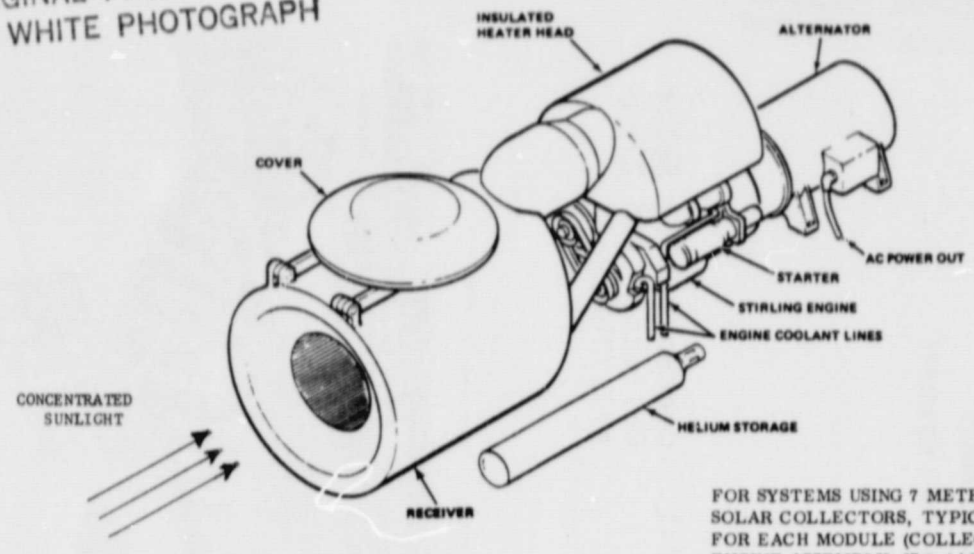


Figure 2-4. Typical Engine Distributed Generation (Engine at Collector Focal Point)

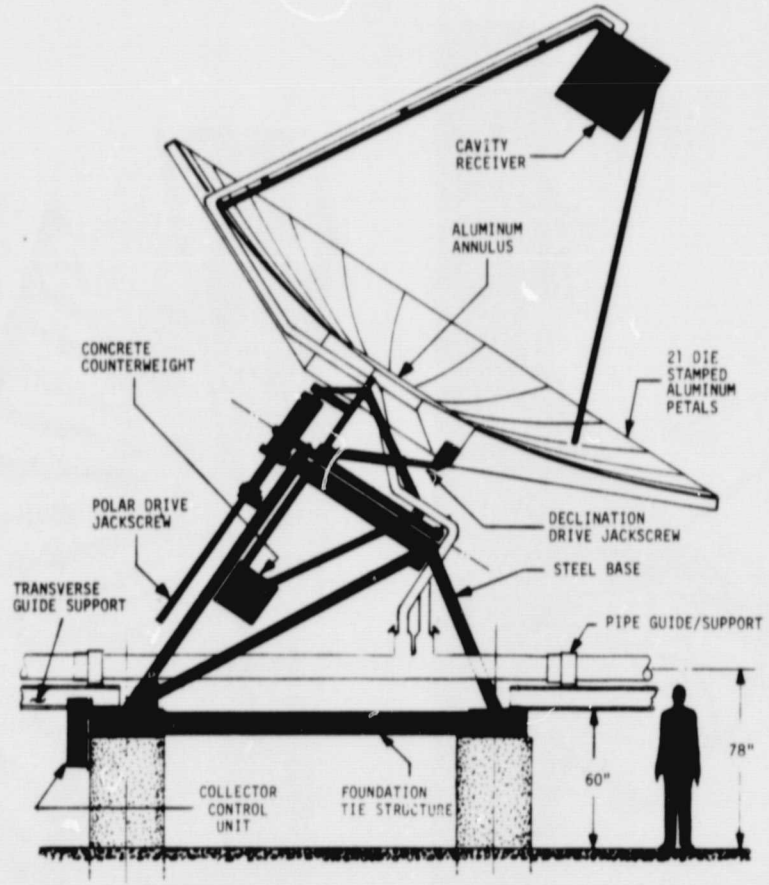


Figure 2-5. Typical Collector Details (Central Generation)

ORIGINAL PAGE IS
OF POOR QUALITY

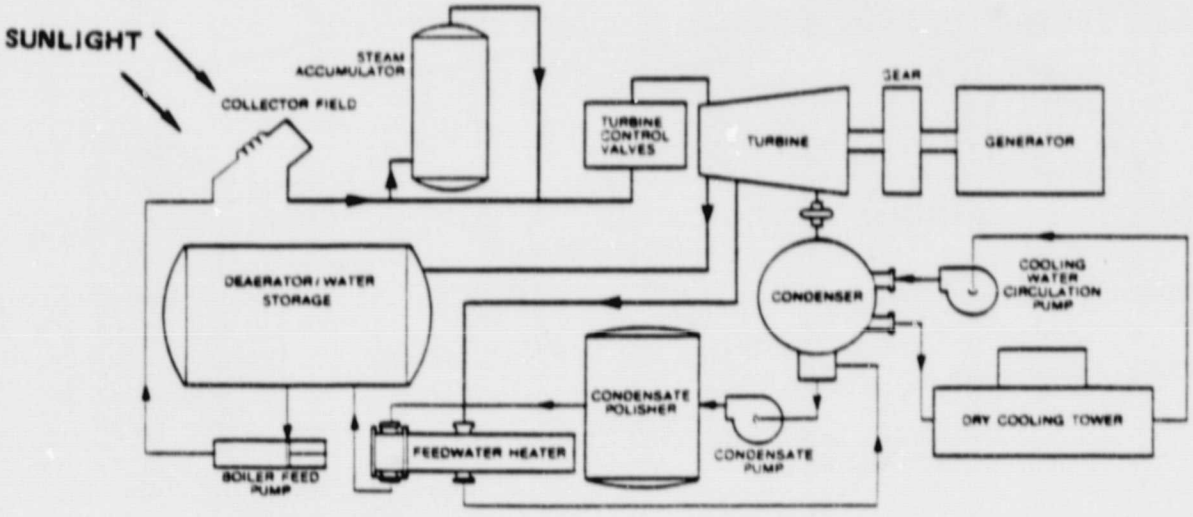
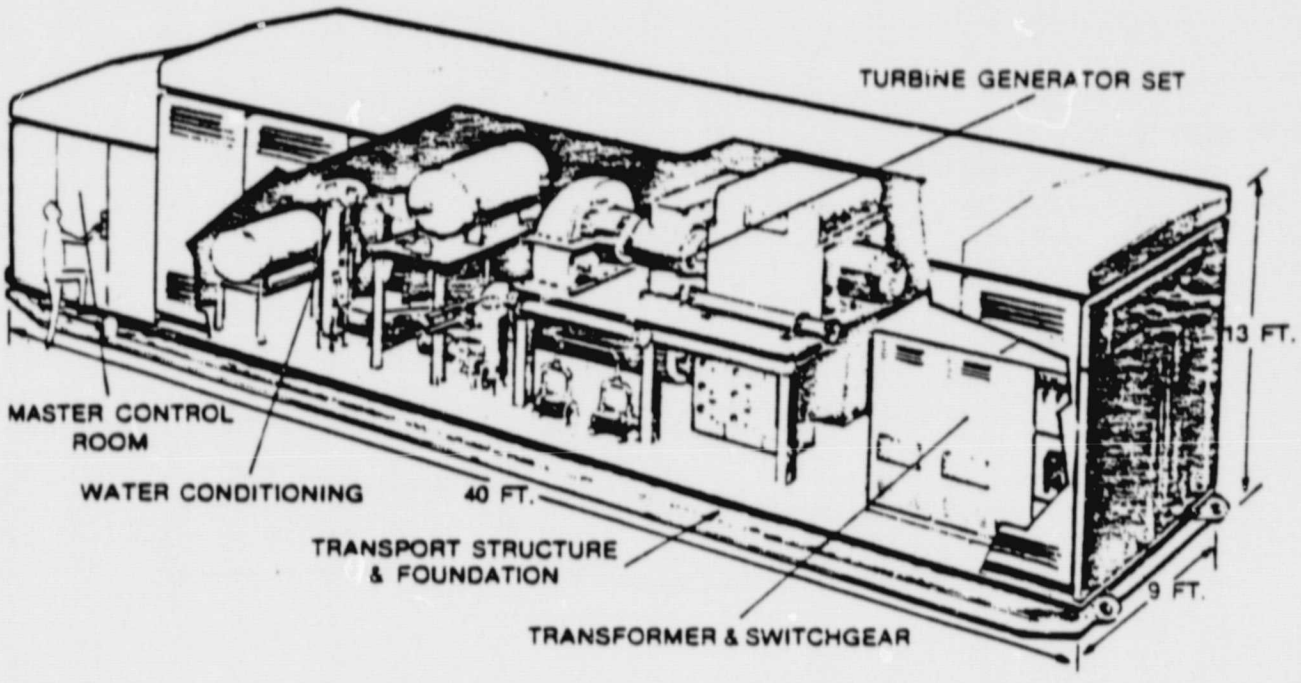


Figure 2-6. System Schematic Central Generation

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH



STEAM SUPPLY (700 PSIA 750°F) FROM 150 to 300 7-METER SOLAR COLLECTORS (DEPENDING ON INSOLATION LEVEL, STORAGE CAPACITY AND SYSTEM CAPACITY FACTOR.)

Figure 2-7. 1 MW Central Generation Power Module

Steam: 60 to 70 kW (condensing)

Power: 4 to 5 kW (condensing)
-2.5 to 4 kW (cogeneration)

Basic system characteristics were defined as:

- Concentrating high temperature solar collectors
- 1 to 10 megawatt output
- Process steam available in several system options - approximately 15-25,000 lb/hr per megawatt
- 40% capacity factor from solar input only
- Supplemental fossil firing (or utility back-up) for higher capacity factor requirements
- Land area required: 8 to 15 acres per megawatt
- Modular and relocatable

Tables 2-1 and 2-2 present cost projections for industrial and electric utility applications provided to study participants in the three selected solar regions. Firms were given data only for their solar region and applicaiton, i.e., industrial or electric utility use.

Assumptions used in developing the system prices, bus bar energy costs, and land requirements were:

- $900/kW for the highest insolation areas, based on JPL-furnished cost projections.

- 8 to 10 acres per megawatt land area required based on the EEl system concepts developed by General Electric, Ford Aerospace, and McDonnell Douglas Astronautics. The land requirement was also based on the highest insolation areas.

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE 2-1

1990 SOLAR POWER SYSTEM COST PROJECTIONS

INDUSTRIAL APPLICATIONS

SUMMARY IN 1979 DOLLARS

	SYSTEM COST ($/kW)	DELIVERED ENERGY COST		LAND AREA REQUIRED (ACRES/MW)
		ELECTRICITY ONLY (¢/kWh)	WITH PROCESS HEAT CREDIT (¢/kWh)	
REGION I	$1300	8 TO 10	6 TO 8	13 TO 15
REGION II	$1100	7 TO 8	5 TO 6	10 TO 12
REGION III	$900	6 TO 7	4 TO 5	8 TO 10

- LAND COST NOT INCLUDED IN SYSTEM PRICE
- ASSUMED 20% FIXED CHARGE RATE
- FORTY PERCENT CAPACITY FACTOR

TABLE 2-2

1990 SOLAR POWER SYSTEM COST PROJECTIONS

UTILITY APPLICATIONS

SUMMARY IN 1979 DOLLARS

	SYSTEM COST ($/kW)	DELIVERED ENERGY COST		LAND AREA REQUIRED (ACRES/MW)
		ELECTRICITY ONLY (¢/kWh)	WITH PROCESS HEAT CREDIT (¢/kWh)	
REGION I	$1300	6 TO 7.5	4 TO 5.5	13 TO 15
REGION II	$1100	5.5 TO 6	3.5 TO 4	10 TO 12
REGION III	$900	4.5 TO 5.5	2.5 TO 3.5	8 TO 10

- LAND COST NOT INCLUDED IN SYSTEM PRICE
- ASSUMED 18% FIXED CHARGE RATE
- FORTY PERCENT CAPACITY FACTOR

- System costs and land requirements were scaled inversely with average daily direct insolation levels for the good and fair regions, II and III, respectively.

- Nominal fixed charge rates (FCR) of 24 and 18 percent were used for industrial and utility applications, respectively, to determine bus bar energy costs (i.e., FCR multiplied by system cost and divided by the product of capacity factor and 8.760 hours per year). The 18% value for utilities is that recommended by EPRI for utility applications. The factor of 24% for industrial firms is an estimate of the higher cost of capital to such organizations.

- Capacity factor of .4 from solar input was maintained for all three solar regions (storage is required in all regions to meet this capacity factor).

- Process heat credit was assumed to decrease the net cost of electricity by two cents per kilowatt hour, based on previous General Electric studies. This is a conservative estimate. In many applications, the value of the process heat can equal or exceed that for the electrical output.

2.3 STUDY APPROACH

The overall objective of the market survey task was to identify and measure attitudes, reactions and intentions of prospective users of Solar Thermal Power Systems at the one to ten megawatt level. In order to meet the objectives, the following steps were undertaken:

1. Identify potential users
2. Identify variables relative to potential market segments
3. Segment the market

4. Identify and construct product related variables for each of the market segments
5. Design and implement the survey.

2.3.1 IDENTIFICATION OF POTENTIAL USERS

In an effort to assess the commercialization prospects of a given product or technology potential users must be identified. Those who currently use a product or technology to produce the same end product (e.g., electrical energy) may find it beneficial and/or cost effective to become producers of the end product for their own consumption. For Small Solar Thermal Power Systems, potential applications include utility, industrial, commercial (e.g., offices, stores) and institutional (e.g., schools, hospitals) users. Utilities and industrial firms were identified as the segments with highest potential for adaptation of Solar Thermal Power Systems. This is based upon a combination of factors such as power usage, land availability, and operation and maintenance capability.

Market Segmentation - Within the gross segments (Utility and Industrial), subsegments exist. For utilities, the principal differenct is ownership type, which is the basic factor in many of a utility's policy decisions. The utility subsegments selected for this study were:

- Private, Investor Owned
- Rural Electric Cooperatives
- Municipal Systems

Rural cooperatives and municipally owned utilities typically have much lower fixed charge rates than do the investor owned utilities. This is primarily due to their effective exemption from federal taxes. The lower fixed charge rate reduces the annual ownership costs, particularly for a capital-intensive device such as SPS.

Industrial subsegments are commonly defined by Standard Industrial Classification (SIC) groups, with data on electrical consumption and generation patterns available by SIC group (at least to the two-digit level). This allows a definition of "total" or universe size for the segment. Secondary data sources (primarily the Census of Manufactures) were used as data sources for nine industrial subsegments:

SIC 33 Primary Metals
SIC 28 Chemicals
SIC 26 Paper
SIC 20 Food
SIC 37 Transportation Equipment
SIC 22 Textiles
SIC 32 Stone, Clay and Glass
SIC 29 Petroleum and Coal
-- All Other

As shown in Table 2-3, the top eight SIC groups account for 77 percent of all industrial consumption and 97 percent of in-plant generation. Appendix C contains a summary by State and SIC of inplant generators.

The second segmentation variable is product related and deals with location. For SPS, solar insolation factors combined with system performance determine system costs, land requirements and delivered energy costs. Insolation levels were used to assign each of the fifty states to one of three solar regions, i.e., "best", "good", and "fair" assigned on the basis of average daily direct insolation levels for each state. Table 2-4 presents the separation of states into these three solar regions.

These regions were overlaid on the previously identified utility and industrial segments resulting in a total of nine utility and twenty-seven industrial segments. Table 2-5 separates the three major classes of electric utility ownership by their

TABLE 2-3

INDUSTRIAL ELECTRICAL CONSUMPTION AND GENERATION BY SIC GROUP

	Industry	Purchased	Generated	Cumulative % of Total	
				Purchased	Generated
33	Primary Metals	121,403.5	24,643.3	23.8	30.0
28	Chemicals	99,633.6	19,563.4	43.3	53.9
26	Paper	34,910.4	25,457.2	50.1	84.9
20	Food	33,786.3	2,660.1	56.7	88.1
37	Trans. Equip.	27,532.2	---	62.1	88.1
22	Textiles	24,927.4	470.7	67.0	88.7
32	Stone, Clay & Glass	24,774.3	882.9	71.9	89.8
29	Petroleum and Coal	23,590.5	5,580.7	76.5	96.6
36	Electrical Equipment	23,482.9	147.4	81.1	96.8
35	Machinery	22,312.5	371.1	85.4	97.2
34	Fab. Metal Products	19,840.6	113.5	89.3	97.4
30	Rubber and Plastics	15,240.5	629.6	92.3	98.1
24	Lumber and Wood	11,044.7	1,196.2	94.5	99.6
27	Printing	9,071.2	29.5	96.3	99.6
23	Apparel	5,748.1	15.5	97.4	99.6
39	Miscellaneous	3,743.9	84.0	98.1	99.7
38	Instruments	3,626.9	---	98.8	99.7
25	Furniture	3,626.4	78.3	99.5	99.8
31	Leather	1,487.1	41.3	99.8	99.8
21	Tobacco	907.7	102.9	100.0	100.0

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE 2-4

STATES GROUPED BY AVERAGE DAILY DIRECT INSOLATION LEVELS

Region	Region I Fair Insolation for SPS		Region II Good Insolation for SPS	Region III Best Insolation for SPS
Daily Direct Insolation Range kWh/m^2	3.5 to 4.5		4.6 to 5.5	5.6 to 7.5
States in Region	Alabama Alaska Connecticut Delaware District of Columbia Florida Georgia Illinois Indiana Kentucky Louisiana Maine Maryland Massachusetts Michigan Minnesota	Mississippi New Hampshire New York North Carolina Ohio Oregon Pennsylvania Rhode Island South Carolina Tennessee Vermont Virginia Washington** West Virginia Wisconsin Wyoming	Arkansas Idaho Iowa Missouri Montana Nebraska North Dakota Oklahoma South Dakota Texas	Arizona* California Colorado Hawaii* Kansas New Mexico Nevada Utah
Total	32		10	8

*> 7.5

**< 3.5 kWh/m^2

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE 2-5

NUMBER OF UTILITIES BY SELECTED OWNERSHIP CLASS IN EACH SOLAR REGION

Solar Region	Investor Owned	Municipals	Rural Elec. Coops	Total
I - Fair	172	1,012	514	1,817
II - Good	45	514	321	949
III - Best	27	221	98	376
Total	244	1,747	933	3,142

TABLE 2-6

NUMBER OF INDUSTRIAL ELECTRIC CUSTOMERS BY SOLAR REGION

Solar Region	Number	Percent
I - Fair	281,879	66.0
II - Good	84,058	19.6
III - Best	61,466	14.4

assigned solar region, while Table 2-6 clearly shows the preponderance of industrial electricity consumers to be located in states with average daily direct insolation from 3.5 - 4.5 kWh/m^2.

It might be expected that there will be an increase in the number of customers, with time, in the "good" and "best" regions based upon migration to the sunbelt states.

2.3.2 SURVEY FORMAT

The secondary data search (see Appendix D) was used as a base for constructing the questionnaire to measure potential user interest in Small Solar Thermal Power Systems. Booklets describing and explaining the system, its features and related costs were prepared for industrial and electric utility applications. Specific sets of brochures and questionnaires were tailored to the three selected solar regions. All materials prepared were reviewed extensively with personnel of the GE Electric Utility Sales (EUSD) and Industrial Sales Divisions (ISD) for clarity, completeness and relevance. Field sales engineers of these two sales divisions used this material in conducting personal interviews.

The questionnaire format and presentation booklets were designed to elicit maximum information with minimum bias. Appendix B contains copies of all materials used in the market analysis survey tasks.

Respondents were not asked to give a technical evaluation of the SPS nor to select the "better" of two alternatives, i.e., the electric only configuration versus an electric and thermal output design. Preferential design elements were inferred by the stated needs of the respondent companies.

Questionnaire areas included:

- Current and future energy needs
- Plans for meeting future requirements
- Opinions on future availability and cost of fuels
- Importance of and performance by proposed SPS on identified system factors
- Reaction to SPS (benefits, drawbacks)
- Interest in acquiring SPS
- Financial criteria to be met
- Land cost

Three methods were used in collecting the information.

1. Personal Interviews by General Electric EUSD and ISD Salesmen. These interviews were conducted with General Electric customers by sales engineers familiar with the participating companies, their needs and attitudes. This approach provided the base data described above, allowed for in-depth discussion of the system and identified any problems and/or concerns that were present. Comments made by the involved sales engineers helped to assess the quality of response, and also contained their own views and comments on the SPS. The survey included approximately 75 of these personal interviews.

2. Mail Survey. The bulk of the data was collected via mail questionnaires. This method was deemed appropriate for this study since it allowed contact with more companies that would have been practical for GE sales engineers to cover. In addition, the survey included prospective users regardless of their status as GE customers.

Several steps were taken to assure a high response rate:

1. GE was identified as the study sponsor.
2. Companies were contacted prior to the mailing to determine the name and title of the proper survey recipient; mailings were personally addressed.

3. The mailing included a personalized letter from the Program Manager soliciting the respondent's participation in the study.
4. The mailing contained a photo of Jupiter taken from the Voyager spacecraft as an added incentive. A full set was made available to respondents upon request.
5. Self-addressed, stamped return envelopes were included in the mailing.
6. Confidentiality of the data furnished by survey participants was guaranteed. This factor precluded identification of specific firms which participated in this survey.

This approach helped to personalize the request for information and had proven successful in previous studies. After a reasonable period of time, all who had not responded were contacted to verify receipt of the survey package. Duplicate mailings were sent to anyone who had not received the original mailing.

3. Telephone Surveys. Telephone interviews were conducted by professional interviewers in those cases in which the survey package had been received, and the respondent preferred such an interview rather than returning the completed questionnaire. This technique proved to be highly effective in obtaining data from firms which otherwise would have not participated in the study.

2.3.3 THE SAMPLE

As noted previously, the total market was divided into 36 segments (9 utility and 27 industrial). The sampling design was stratified random sampling with the strata defined as the market segments. Sample sizes were pre-determined on a judgemental basis to provide sufficient depth for detailed analysis by major strata (i.e., Solar Region, I, II, or III), SIC group, utility

ownership classification). The major purpose of this approach was to assign variations (if any existed) to either an industry/utility segment or a region (i.e., is high interest in the concept associated with the xyz industrial or is it a function of the solar region or are both criteria involved).

Utilities - In order to draw the sample, utilities were ordered by ownership class by State, within each solar region classification. The mail survey sample was selected on a random basis. Table 2-7 shows sample sizes and base counts. The sample for personal interviews was selected in the same manner by first eliminating from the order all utilities previously selected for the mail survey. The selected sample was then reviewed for GE customer status; non-customers were eliminated and replaced with new sample selections. Each set of new additions was checked for customer status until the desired sample size was achieved.

Industries - As noted previously, "best" potential for any product is found among those currently using an alternate technology to produce a similar end product. For this reason, it was desired to include in the study industries currently generating their own power. This group was judged to have good near-term potential for use of Solar Thermal Power Systems because of their experience and expertise in utility interface, and their demonstrated need and corporate policy regarding in-plant generation. In order to evaluate those industrials currently generating power, Federal Government reports were used. These reports separately identify all generators, by name and location of generating equipment, for capacities of under 5 MW and over 10 MW. (Data on 5-9 MW is not in published format).

A numerical summary of this data is given in Appendix A. Table 2-8 shows numbers of industrial generators by SIC and solar region. The sample size was selected as 100. After determination of the sample matrix, all available companies were ordered within their cell structure, and the selection was made on a random basis. The generator sample matrix is shown in Table 2-9.

TABLE 2-7

UTILITY SAMPLE

Cell Size, N=150	Investor Owned	Municipals	REC	Total
Region I	10	26	14	50
Region II	10	25	15	50
Region III	10	28	12	50
Total Sample	30	79	41	150
Sample Base By Regions				
Region I	172	1012	514	1817
Region II	45	514	321	949
Region III	27	221	98	376
Total Utilities	244	1747	933	3142

TABLE 2-8

INDUSTRIAL GENERATORS

Distribution by SIC, Solar Region and Generating Capacity										
SIC	Region I <5MW	Region I >10MW	Region I Total	Region II <5MW	Region II >10MW	Region II Total	Region III <5MW	Region III >10MW	Region III Total	Total
33	16	24	40	0	6	6	0	8	8	54
28	31	34	65	6	7	13	6	4	10	88
26	49	86	135	2	8	10	0	6	6	151
20	35	11	46	7	4	11	11	5	16	73
37	3	2	5	2	0	3			0	8
22	14	9	23	1	0	1			0	24
32	9	9	18	1	2	3	2	1	3	24
29	1	9	10	9	8	17	0	2	2	29
1 Other	91	14	105	26	1	27	10	3	13	145
Total	249	198	447	55	36	91	29	29	58	596

TABLE 2-9

SAMPLE CELL SIZES

Generators N=100 (Mail Survey)										
SIC	Region I <5MW	Region I 10MW+>	Region I Total	Region II <5MW	Region II >10MW	Region II Total	Region III <5MW	Region III 10MW+>	Region III Total	Total
33	4	5	9	0	2	2	0	4	4	15
28	3	4	7	2	2	2	2	2	4	15
26	5	5	10	1	2	3	0	2	2	15
20	1	1	2	1	1	1	4	2	6	10
37	2	2	4	1	0	1			0	5
22	2	2	4	1	0	1			0	5
32	3	2	5	1	1	2	2	1	3	10
29	0	4	4	1	4	5	0	1	1	10
All Other	4	1	5	5	0	5	5	0	5	15
Total	24	26	50	13	12	25	13	12	25	100

ORIGINAL PAGE IS
OF POOR QUALITY

Following completion of the generator sample, a matched sample of non-generating plant locations was constructed. This sample (100) was selected by using the Dun and Bradstreet data base, eliminating known generators and matching the plants on the basis of 4-digit SIC codes as closely as possible to the generator sample. Sample selection was then made on a random basis from available plants. The sample matrix of non-generators is shown in Table 2-10.

In summary, the industrial sample for the mail survey was 200 plants, 100 known in-plant generators and 100 assumed non-generators. Selected to encompass the major energy consuming SIC's in the three solar regions.

Samples for the personal interviews conducted by GE Industrial Sales division field sales engineers was selected similarly to the method outlined above restricting the interviews to GE customers.

Design Engineering Firms - Sample selection of seventy firms was based on their size and relative importance to selected industries. Data gathered was qualitative and used as background information only. No critical sampling plan was required for this group, however, firms were selected on the basis of their background in designing power plants for industrial and utility clients, as well as their involvement in the international market.

Results - Survey results were edited, coded, key punched and tabulated using standard market research techniques. This data was used in the market demand model.

2.4 STUDY RESULTS

This section presents the major findings resulting from the market study described in the previous section. In the industrial sector, 240 firms were contacted. Data were obtained from

TABLE 2-10

CELL SIZE

Non-Generators N=100 (Mail Survey)				
SIC	Region I	Region II	Region III	Total
33	9	2	4	15
28	7	4	4	15
26	10	3	2	15
20	2	2	6	10
37	6	2	2	10
22	4	1	0	5
32	3	1	1	5
29	1	3	1	5
All Other	8	7	5	20
Total	50	25	25	100

143 firms representing fourteen SIC codes, and located in twenty six states. Of these responses, 49% were located in the fair Solar Region I (see Table 2-4 for a listing of these states) and the remainder were divided equally between the good (Solar Region II) and best (Solar Region III) locations. Identical information and data were solicited from all firms, either by personal interview or by the mail survey. All data were coded for statistical analysis and for use as input data to the demand model.

In the electric utility sector, 200 firms were contacted. These firms were about equally divided in the major ownership classes (investor-owned, rural electric cooperatives, and municipal systems).

Seventy design engineering firms which are heavily involved in design of power plants were contacted, and over sixty percent participated in the study. Qualitative data and their views on SPS and its application in the domestic and international market were solicited.

2.4.1 INDUSTRIAL FIRMS

Data on current and projected 1990 electricity consumption, peak power requirements, process steam use, and proportion of inplant generated power were acquired in the market study. Table 2-11 presents the mean values of these key parameters obtained. The large mean value of process steam required (1.4 million pounds per hour) brings out the fact that in order for solar thermal systems to supply a significant portion of the load (e.g., 30% of the steam needed during daytime peak hours by an average plant), almost 200 acres of land would be required in the best solar region of the country.

TABLE 2-11

AVERAGE INDUSTRIAL RESPONSES ON ELECTRICAL REQUIREMENTS

REQUIREMENTS	VALUE	UNITS
CURRENT ANNUAL ELECTRIC CONSUMPTION	280	MWH
ESTIMATED ANNUAL ELECTRIC CONSUMPTION IN 10 YEARS	310	MWH
PEAK REQUIREMENTS	51	kW
ESTIMATED PEAK REQUIREMENT IN 10 YEARS	63	kW
PROCESS STEAM: PRESSURE REQUIRED	259/159/114	PSIA
PROCESS STEAM: MAXIMUM QUANTITY REQUIRED	1.4×10^6	LBS/HR
PERCENTAGE OF TOTAL ELECTRIC REQUIREMENT CURRENTLY GENERATED IN-PLANT	34	%
PERCENTAGE ESTIMATED TO BE GENERATED IN-PLANT IN 10 YEARS	38	%

RANKING

A – BY PRODUCT OF STEAM PRODUCTION
B – NON-INTERRUPTIBLE POWER
C – LESS EXPENSIVE THAN PURCHASED POWER
D – INEXPENSIVE FUEL SOURCE
E – OTHERS

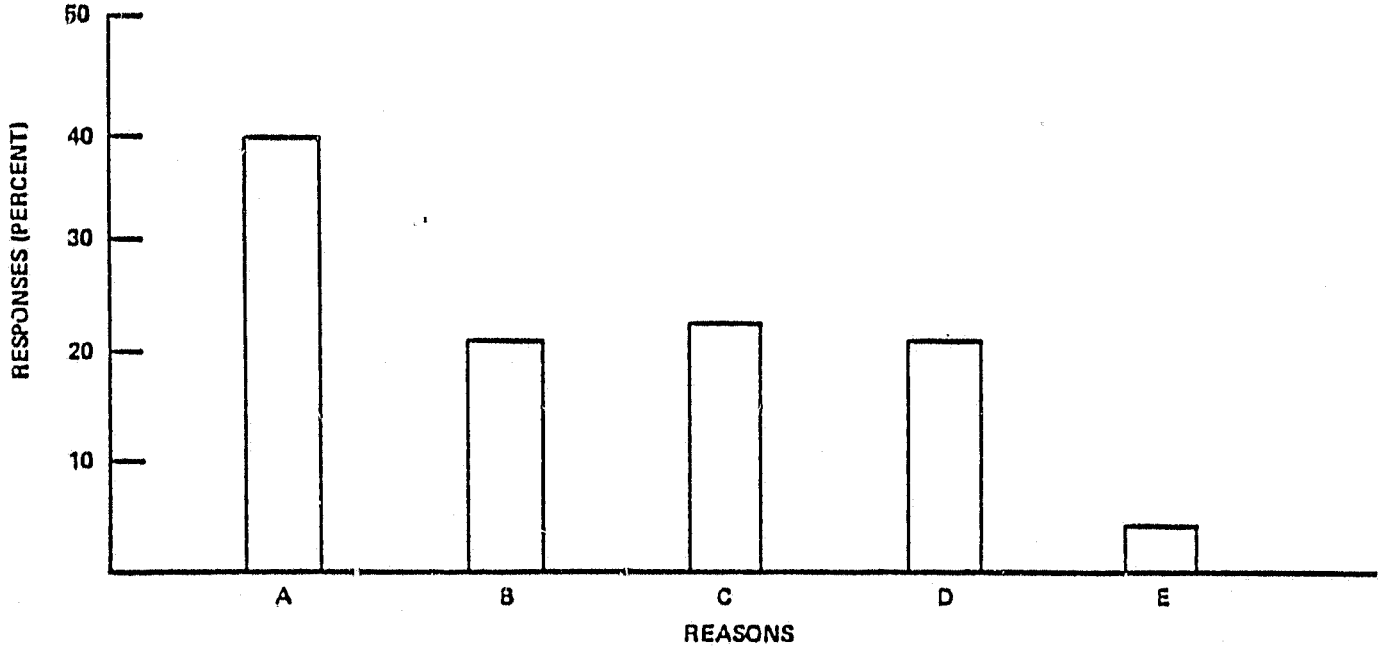


Figure 2-8. Primary Reason for In-Plant Generation

Primary reasons for in-plant generation were determined from responses of industrial firms which now generate all or some of their electric power requirements. Reasons stated in descending order of importance include (1) generation is a by-product of steam production, (2) it is less expensive than purchased power, (3) it provides a non-interruptible power source, or (4) the firm has an inexpensive fuel source. Figure 2-8 illustrates these findings.

Plans for the Future - Information on plans for dealing with future energy requirements was also solicited, and provided data on plans for conversion to other fuel types, adding or replacing existing in-plant generation equipment, or purchasing of greater proportions of electrical needs. A major shift to coal is evident in the high number (48%) of respondents who disclosed plans for fuel conversions. Over 20% plan to convert from present sources to gas. Also, a trend toward use of waste heat, by-product fuel sources, and toward all-electric systems was evinced. Table 2-12 summarizes responses on questions relating to options for dealing with future energy requirements.

TABLE 2-12

CONVERSION TO OTHER FUEL SOURCES

Conversion to coal	48.7%
Conversion to gas	20.5
Use of waste heat	2.6
Use of blast furnace gas	5.1
Conversion to all by-product fuel	2.6
Conversion to all wood	2.6
Conversion to all electric	5.3
Conversion to oil	7.8
Conversion to geothermal	2.6

SPS Applications - More than half (56%) of the industrial firms participating in the market study felt that the SPS would be considered as an industrial power generation option their firm would consider in the 1990 time frame. This high level of positive responses is viewed as a reflection of industrial sector

willingness to accept alternate energy systems as a partial solution to fossil fuel scarcities and price escalations. Major application envisioned for the SPS, by a wide margin, was as an addition to present generating capacity. The second most stated application was as a replacement for present generating equipment now on-line. SPS use to repower existing power plants was the third most cited application. Table 2-13 summarizes these findings.

TABLE 2-13

SPS CONSIDERATION AS INDUSTRIAL POWER GENERATION OPTION IN 1990

56% Positive Reaction Among Generators and Non-Generators
System Most Likely Considered as:

- Addition to Present Generating Capacity (59%)
- Replacement for Generation Equipment Now On-Line (27%)
- System Used to Repower Exciting Power Plant (21%)

Influence Factors - Due to multiple answers by some firms, the applications cited in Table 2-13 total over 100%. Most potential users see the SPS as a supplemental source of energy, i.e., when the solar resource is available and the system is operating, one can displace fossil fuel consumed or electricity purchased by the amount of power being produced. Industrials viewed the SPS about equally as a replacement power plant and as a repowering option.

Each participant in the market study was asked to rate 21 factors relating to the SPS in accordance with how influential these items would be in consideration of the purchase of such solar system. The individual ratings were scored from 0 for "not at all influential" to 10 meaning "extremely influential". These factors are listed in Table 2-14.

TABLE 2-14

LIST OF POSSIBLE INFLUENCING FACTORS

1. Protection against fuel price escalation
2.* Initial price per kilowatt
3. Appearance - aesthetics of the system
4. Demonstrations of system operation in your solar region
5.* Land requirements (acres per megawatt)
6. Your own company's energy policy
7. Pollution credits and/or meeting local standards
8. Meeting your company's financial criteria for capital investment
9. Tax credits
10. The availability of process steam (or thermal energy) from the system
11. Protection against fuel curtailment
12. Accelerated depreciation
13. Modularilty and relocatability of the system
14. Loan guarantees
15. Lower operating costs than conventional systems
16. Easily fossil fired to achieve high capacity factor
17. Low interest loans
18. Land costs within your area
19. Usability of system to repower existing plants
20. Reasonable exchanges with local utilities selling excess/purchasing additional power
21.* Delivered cost cents per kilowatt hour of electricity (excluding process steam credit)

*varied by region

The system price, land requirements, and busbar energy costs shown for items 2, 5 and 21, respectively, were tailored to each solar region and ownership type (industrial or utility).

The respondents were also asked to rate how well the SPS meets the firms' needs or requirements with regard to each factor, eliminating those which were not applicable, i.e., questions 4, 9, 12, 14, 17, 18, and 20.

Influence factors can be categorized as financial, technical, and policy. Financial factors are of most significance as shown in Table 2-15 where the factors are listed in descending order of importance.

Factors influencing purchase decisions versus SPS meeting the firms' requirements, in descending order of disparity or non-attainment, are:

- Financial criteria for capital investment
- Land requirements
- Initial SPS price ($/kW)
- Busbar energy cost (¢/kWh)
- Operating costs
- Repowering existing plants
- Fossil firing ability
- Company's energy policy
- Protection against fuel curtailment
- Availability for process steam

Influencing factors exceeding the firms' requirements were appearance of the system and pollution credits. It is significant that the factor most heavily influencing consideration of SPS purchase is meeting the firm's financial criteria for capital investment, and the perception of how well the SPS meets this need or requirement has the highest value of non-attainment. The top five non-attainment factors are financial in nature.

TABLE 2-15

INDUSTRIAL RANKING OF INFLUENCING FACTORS

Ranking	Factor
1	Meeting company's financial criteria
2	Lower operating costs than conventional systems
3	Tax credits
4	Busbar energy cost
5	Easily fossil fired for higher capacity factor
6	Accelerated depreciation
7	Initial price ($/kW)
8	Demonstrations in local area
9	Protection against fuel curtailment
10	Company's own energy policy
11	Requirements
12	Protection against fuel price escalation
	Of lesser importance in influencing SPS purchase are the following:
13	Pollution credits and/or meeting local standards
14	Low interest loans
15	Usability of system to repower existing plants
16	Availability of process steam/heat
17	Land costs
18	Reasonable exchange of excess power with local utilities
19	Loan guarantees
20	Modularity and relocatibility
21	Appearance - aesthetics of system

Other factors which would influence SPS purchase considerations (in descending order of importance) were:

- Tax credits
- Accelerated depreciation
- SPS demonstrations in local area
- Low interest loans
- Land costs
- Excess power exchange with local utility

Response Ranking by SIC Code - In the industrial sector, the largest number of positive responses regarding possible consideration of purchase of SPS in the 1990-time frame were received from chemical firms (SIC-28) participating in the study. The paper firms (SIC-26), food (SIC-20), primary metals (SIC-33) and the stone-clay-glass (SIC-32) followed. However, primary metals and paper both had the highest number of negative responses as well. Table 2-16 presents a summary of positive and negative responses by SIC codes.

Benefits and Drawbacks - All participants in the market study were asked their reactions to the SPS as described. Benefits offered by the system as well as drawbacks were solicited. Many very similar responses to both questions were received from participants throughout the U.S. These were open-minded questions so the frequencies of identical responses is considered significant. The most frequently mentioned benefits were (1) fuel availability, (2) protection from fuel curtailments and, (3) fuel price protection. The most frequently cited drawbacks were system costs, land cost or availability and low capacity factor (CF) (40% CF from the solar input was used in the system description presented). Figures 2-9 and 2-10 graphically present the major benefits and drawbacks identified.

TABLE 2-16

SPS PURCHASE CONSIDERATION BY SIC CODES

SIC Codes	No	Yes
SIC-10	0	2
SIC-13	1	3
SIC-20 - Food	3	9
SIC-22 - Textiles	1	7
SIC-24 - Lumber and Wood	1	4
SIC-25 - Furniture	1	1
SIC-26 - Paper	12	10
SIC-28 - Chemicals	6	12
SIC-29 - Petroleum and Coal	9	4
SIc-30 - Rubber and Plastics	1	0
SIC-32 - Stone, Clay and Glass	6	8
SIC-33 - Primary Metals	13	8
SIC-34 - Fabricated Metal Products	1	0
SIC-35 - Machinery	2	2
SIC-37 - Transportation Equipment	3	5
SIC-38 - Instruments	0	1
Column Totals	60	76
Total (%)	44.1%	55.9%

ORIGINAL PAGE IS
OF POOR QUALITY

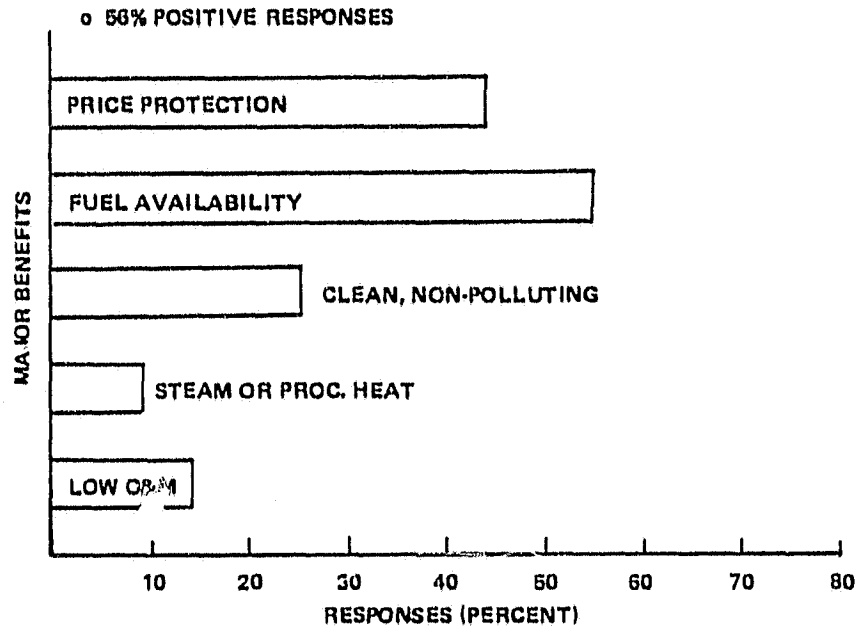


Figure 2-9. Major Benefits Received by Industrial Firms

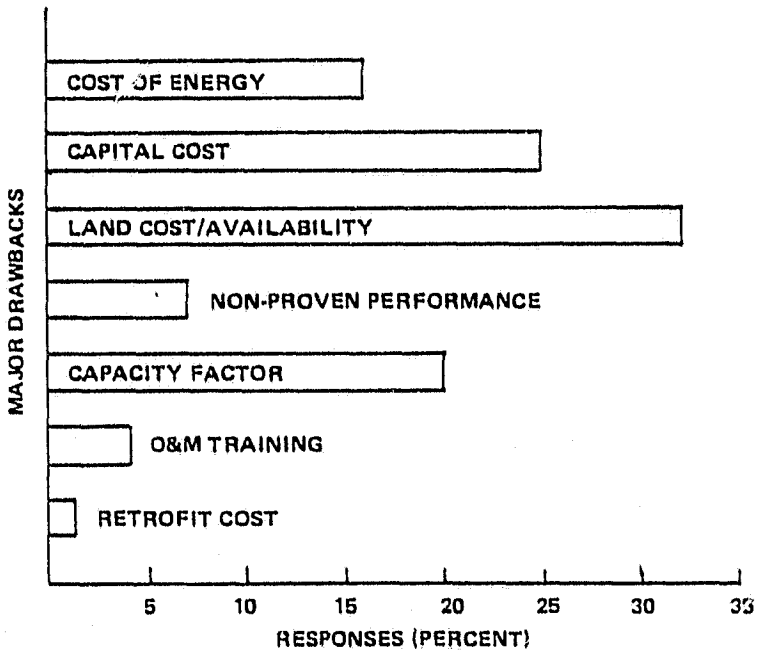


Figure 2-10. Major Drawbacks Perceived by Industrial Firms

Other benefits cited include the public relations value of having such a system. This factor was recognized but would probably not be sufficient reason for a firm to seriously consider purchase of a non-economic SPS since the major factors motivating an affirmative purchase decision were financial in nature.

Each participant was asked if his firm would consider purchase of the SPS as a possible power plant option in the 1990-time frame. If the answer was negative, they were asked to identify majcr reasons. Figure 2-11 presents a summary of these reasons.

Industrial Land Costs - Land for Solar Power Systems must obviously be suitable for system installation and adaptable to the user's existing energy system. For the utility user the latter constraint may only necessitate location along existing distribution lines. For the industrial user, however, the SPS would most likely have to be located adjacent to or very close to the plant to be served. The cost of this land may greatly affect SPS economics. Assuming a nominal land area requirement of ten acres per megawatt, land costs of $1000 per acre add $10/kW to total system cost. At $10,000 per acre this becomes $100/kW and at 100,000 per acre, $1000/kW, roughly equivalent to the total cost for a nuclear power plant.

Land cost estimates were supplied by 102 industrial respondents and encompassed a range from less than $500 to more than $100,000 per acre. Cumulative distribution of the industrial land costs are shown in Figure 2-12. Mean land cost was very close to $20,000 per acre (equivalent to $200/kW), with the median, or mid-point at exactly $10,000/acre. The median better characterizes the land cost distribution than does the mean, since the latter can be greatly affected by a few very high land prices. Shown in Table 2-17 are the percent of industrial respondents at or below the cost level and the percent above the level for several values of land cost.

ORIGINAL PAGE IS
OF POOR QUALITY

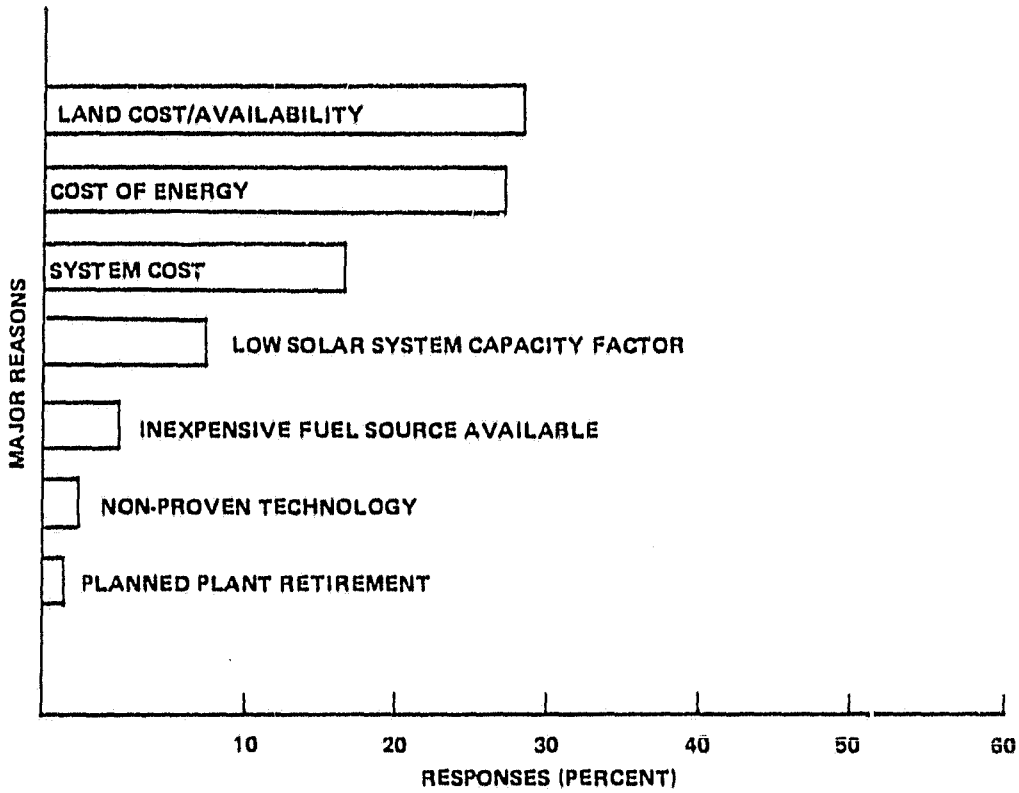


Figure 2-11. Major Reasons for Negative SPS Opinion in 1990-Time Frame by Industrial Firms

ORIGINAL PAGE IS
OF POOR QUALITY

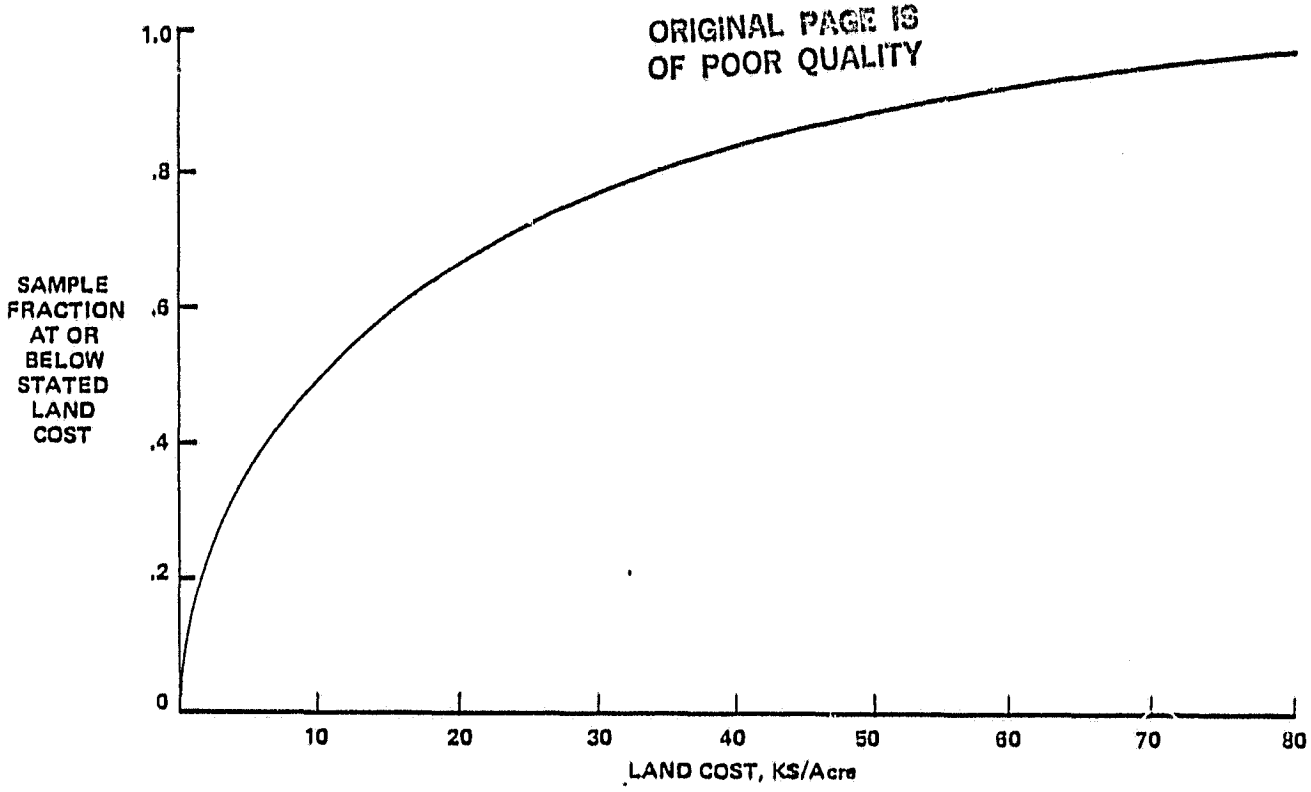


Figure 2-12. Industrial Land Cost Cumulative Distribution

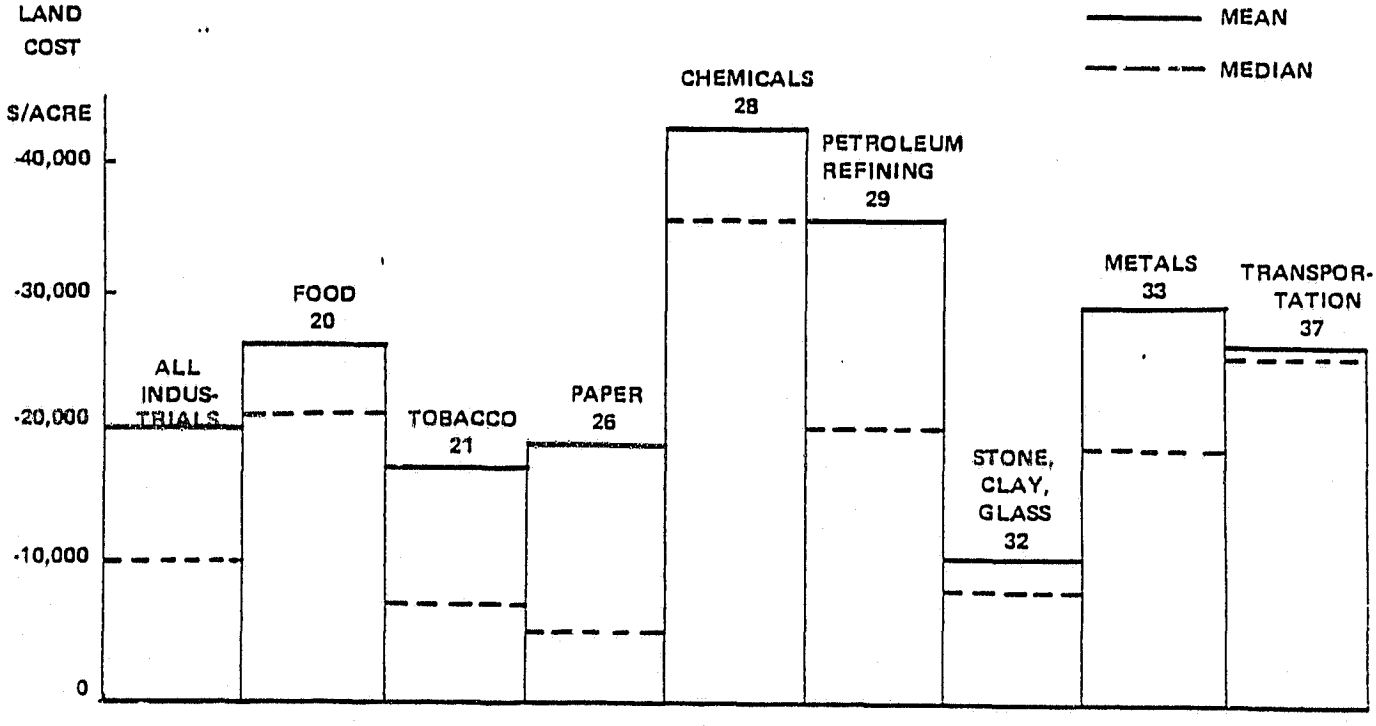


Figure 2-13. Industrial Land Costs Mean and Median by SIC

TABLE 2-17

RANGE OF LAND COSTS

Land Cost $/Acre	Percent of Total Respondents	
	At or Below Cost Level	Above Cost Level
2000	23%	77%
5000	42	58
10000	54	46
20000	67	33
50000	93	7

Figure 2-13 presents mean and median land costs for those SIC categories with a significant number of interview and survey responses. Paper (SIC 26) indicates the importance of the median. Although the average paper industry land cost of $18,400/acre was not significantly different from overall industrial mean of $20,000/acre, the median was only $5000/acre compared to $10,000/acre. Thus, while fifty percent of total industrial land was at or below $10,000/acre, fifty percent of paper industry land was at or below $5000/acre. Chemicals (SIC 28) showed the highest mean and median land costs of the industrial respondents at $42,000 and $35,000/acre respectively. It should be pointed out that, with only 102 total industrial responses, disaggregation to the SIC level involves smaller sample sizes than would be statistically desirable. However, the data are useful to point out industries with characteristically high and low land costs.

Industrial Financial Criteria - Financial investment criteria were supplied by some 72 responding firms. This somewhat low rate can be attributed, in part, to confidentiality requirements of the responding firms. The major factor is that the mail survey forms went to knowledgeable energy people - plant managers, power house superintendents, etc., rather than to financial or accounting personnel. Required return on investment (ROI) and simple payback period were the principal criteria employed. Payback, where specified, was converted to an equivalent ROI, by

ORIGINAL PAGE IS
OF POOR QUALITY

taking the reciprocal and adjusting to an after-tax basis. The resulting cumulative distribution as shown in Figure 2-14. About 60% of the sample fell in the range of 15 to 20% return on investment. It must be noted that interviews and surveys took place in summer and fall 1979 and reflect to a certain extent, the inflation rate of that period, on the order of 12% on an annualized basis. Mean value for industrial responses was a required ROI of 19.3%. Disaggregation by SIC proved to be inconclusive.

Insolation Effects - Average daily direct solar insolation in the United States varies from a Low of 3.2 kWh/M^2 in the state of Washington to a high of 7.5 kWh/M^2 in Arizona. Electrical consumption by the industrial sector is highly concentrated in states with 3.6 - 4.0 kWh/M^2 average daily insolation. There are 25 states falling in this range and, as shown in Figure 2-15, these account for over 60% of industrial electricity consumption, as reported in the 1976 Survey of Manufacturers. Average daily direct insolation for all states is shown in Figure 2-16. California, with 6.5 kWh/M^2 average insolation, and Texas, at 5.0 kWh/M^2, are the principal industrialized states at higher insolation levels. Good applications for Solar Power Systems will undoubtedly exist in these states, but substantial industrial penetration will require systems that deliver competitive energy costs at the 3.6 to 4.0 kWh/M^2 insolation level.

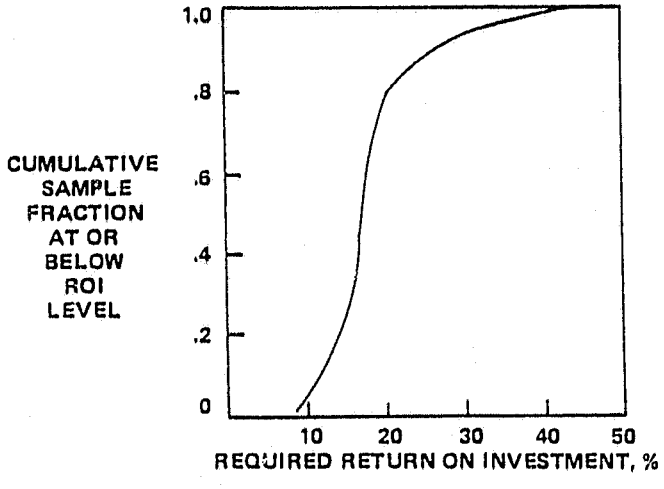


Figure 2-14. Industrial Return on Investment Cumulative Distribution

ORIGINAL PAGE IS
OF POOR QUALITY

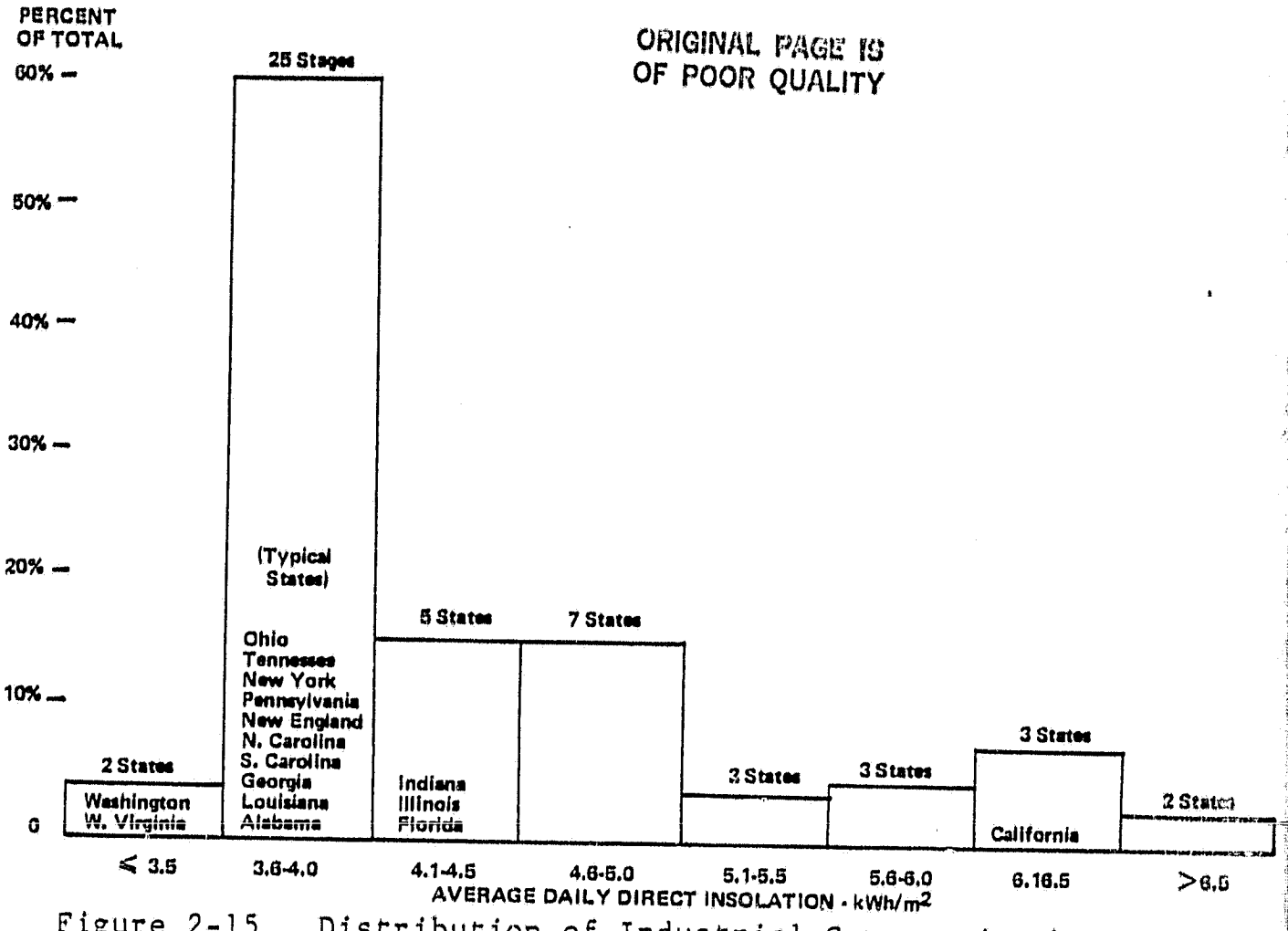


Figure 2-15. Distribution of Industrial Consumption by Solar Region

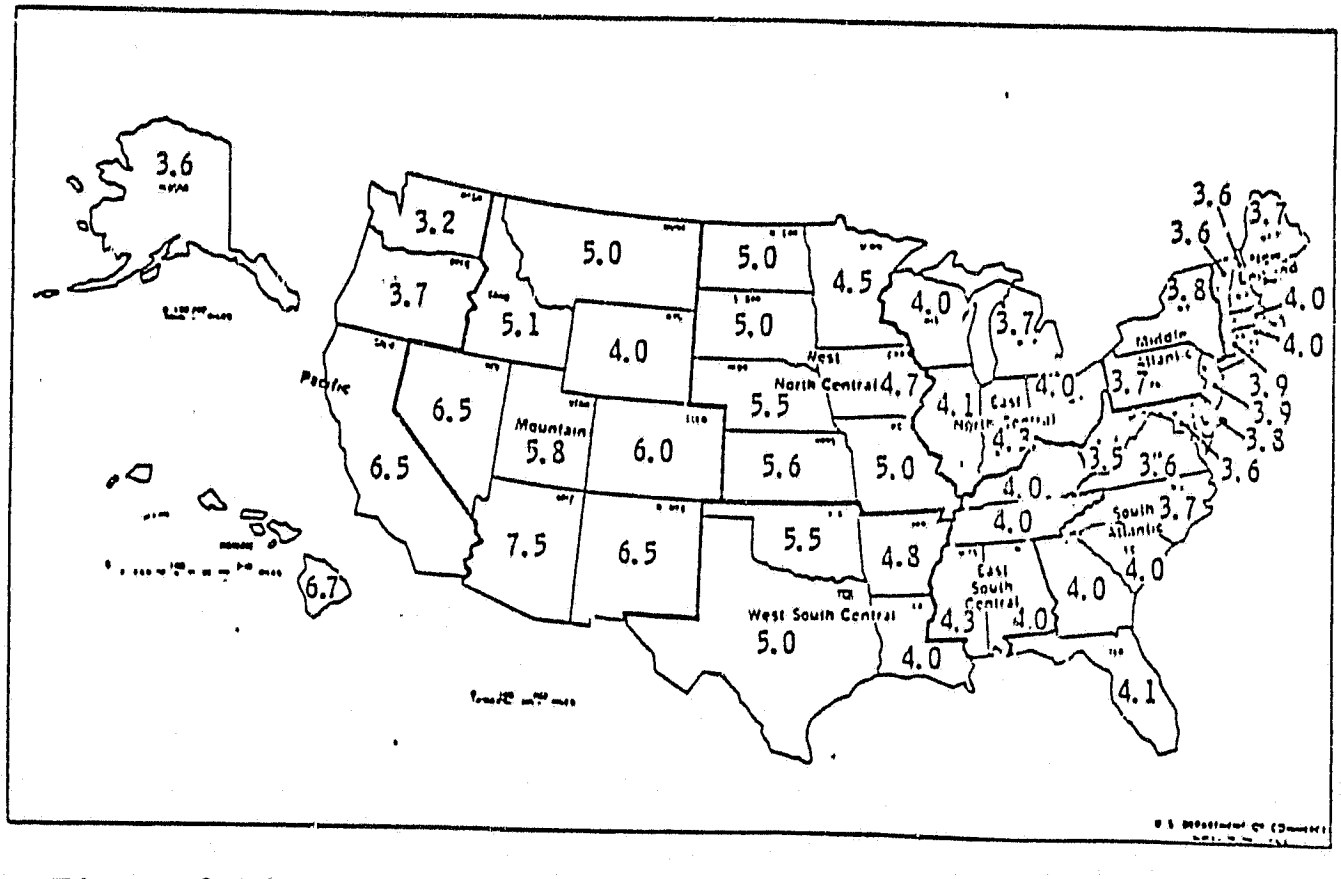


Figure 2-16. Average Daily Direct Insolation (kWh/m^2) by State

Combined Effects of Land Cost and Insolation Level - The combined effects of land cost and insolation level on the delivered, or busbar, cost of energy is shown in Figure 2-17 for the industrial sector. SPS cost was assumed, for calculation purposes, at $600/KW. Land area was assumed at 5 acres per MW for 40% capacity factor at an insolation level of 7.5 kWh/M^2/day average (Arizona). At lower insolation levels, land area and system costs were increased by the insolation ratio, with the 40% capacity factor held constant. Average industrial-required return on investment of 19.3% was used.

The chart clearly shows that, as sunbelt solar power systems become economic, the majority of the industrial sector will have energy costs considerably higher due to lower insolation levels and higher land costs. On the positive side, recent trends of industrial migration to sunbelt states would provide a steadily increasing number of prospective SPS applications.

2.4.2 ELECTRIC UTILITIES

A total of two hundred electric utilities in the three major ownership classes of investor-owned, rural electric coopera-

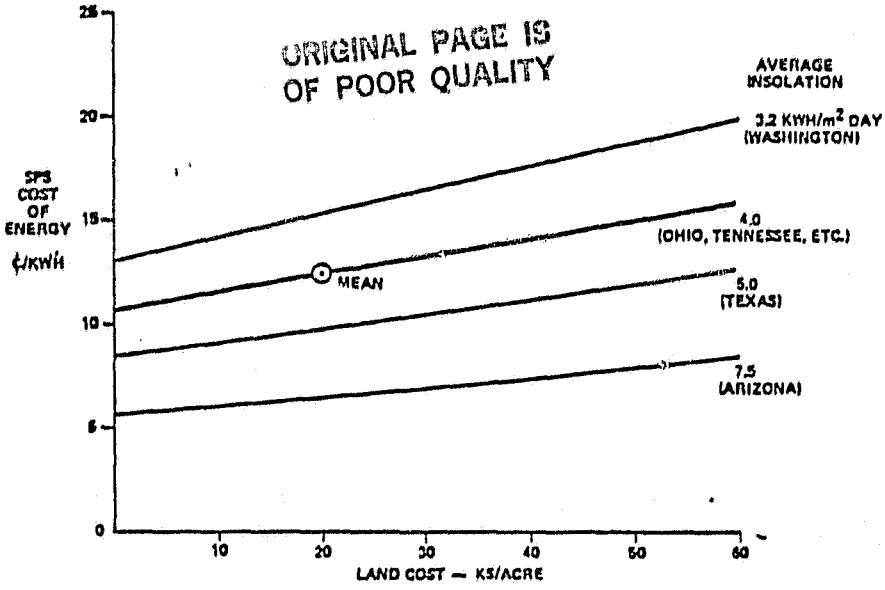


Figure 2-17. Effect of Land Cost and Insolation Level on Industrial Cost of Energy From Solar Power Systems

tives, and municipal systems were contacted. One hundred thirty-four firms participated in the market study, resulting in a sixty-seven percent response rate.

Fifty-four percent (69 out of 128 valid cases) expressed a positive response to the question of whether they would consider an SPS as a power plant option in the 1990 time frame. Of these positive responses 56.5% were municipal systems, 27.5% were investor-owned utilities, and 25.9% were rural electric cooperatives.

Among the utilities with affirmative responses, 76% envisioned use of the SPS as an addition to present generating capacity, 16% as replacement equipment and 14% as a system to repower existing power plants.

Of the firms which stated they would not consider the SPS as a power plant option, the most frequently cited reasons were the initial system cost, busbar energy cost, land cost or availability and system capacity factor. Other important factors cited were non-proven technology for SPS, the fact that the utility was a non-generator (distribution only) or that the utility was too small to generate.

Major SPS benefits cited were fuel availability and energy price protection. The fact that the system was clean and non-polluting, and that it offered transmission savings were important factors also as shown in Figure 2-18.

As shown in Figure 2-19 major drawbacks perceived were system capacity factor (stated as 40%), land cost and availability, and SPS initial capital cost ($/kW). Other drawbacks were the non-proven technology aspect of SPS, busbar energy cost, system capacity at peak power needs, and environmental problems.

A series of 21 system factors were identified (Table 2-18) and firms were asked to rank on a scale of 0 (meaning not influen-

ORIGINAL PAGE IS
OF POOR QUALITY

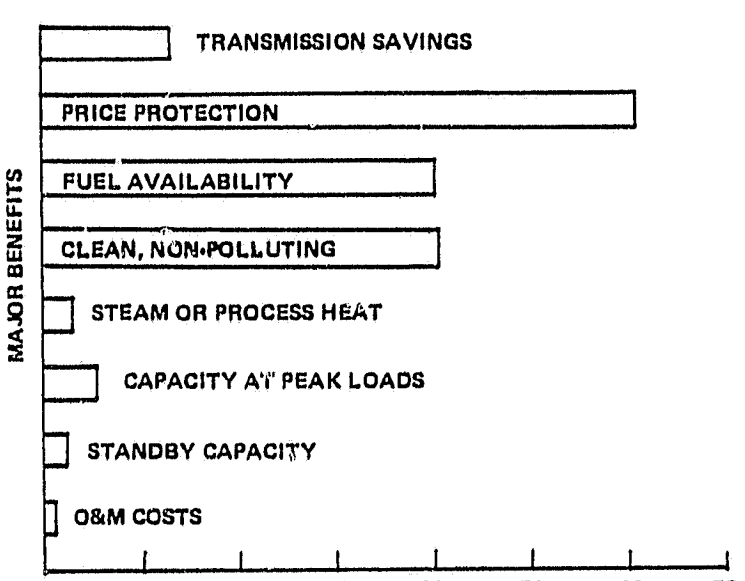


Figure 2-18. Major Benefits Perceived by Utilities

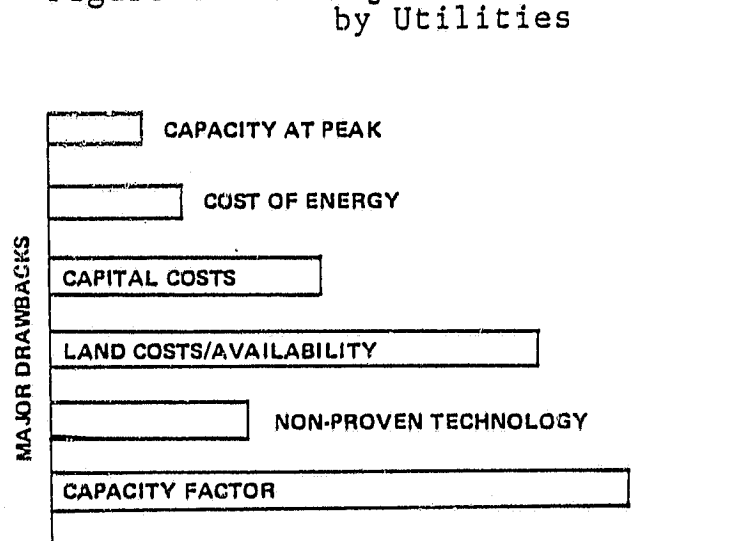


Figure 2-19. Major Drawbacks Perceived by Utilities

TABLE 2-18

SYSTEM FACTORS

1. Protection against fuel price escalation
2.* Initial price per kilowatt
3. Appearance - aesthetics of the system
4. Demonstrations of system operation in your solar region
5.* Land requirements (acres per megawatt)
6. Your own company's energy policy
7. Pollution credits and/or meeting local standards
8. Meeting your company's financial criteria for capital investment
9. Tax credits
10. The availability of process steam (or thermal energy) from the system
11. Protection against fuel curtailment
12. Accelerated depreciation
13. Modularilty and relocatability of the system
14. Loan guarantees
15. Lower operating costs than conventional systems
16. Easily fossil costs than conventional systems
17. Low interest loans
18. Land costs within your area
19. Usability of system to repower existing plants
20. Reasonable exchanges with other utilities for selling excess/purchasing additional power
21.* Delivered cost cents per kilowatt hour of electricity; (excluding process steam credit)

*varied by region

tial) to 10 (extremely influential) the degree of influence each factor would have in consideration of an SPS as a power plant option. The study participants were also asked to rank each factor (except those marked by an asterisk) as to how well the SPS meets the individual utility firm's requirements.

The least influential factor was the availability of process steam. This was not surprising since utilities are in the business of producing electricity and view process steam production as alien to their main business.

The SPS factor which ranked lowest in terms of meeting the company's requirements was the usability of the system to repower existing plants. Among firms indicating a positive interest in the SPS, the repowering application was the least popular option (14%).

The busbar cost of electricity ranked first in terms of influencing consideration of an SPS. Meeting the company's financial criteria for capital investment was next in importance, followed by SPS lower operating costs then conventional systems, land requirements, company's own energy policy, and demonstration in the local area.

The greatest disparities between factors influencing consideration of SPS purchase and meeting the company's requirements was the land requirements (acres per megawatt) factor, followed by meeting the company's financial criteria for capital investment These factors are quite significant, especially the land requirements concern since this factor has been identified also to be the one of the most significant obstacles to market penetration in the industrial sector.

The most disparate factors were:

- Land requirements
- Meeting financial criteria for capital investment

- Busbar cost of electricity
- Initial system price ($/kw)
- Company's own energy policy

Factors which both influenced purchase consideration and met or exceeded the firm's requirements were:

- Modularity and relocatability of system
- Protection against fuel price escalation
- Pollution credits and/or meeting local standards

Responses (frequency and percentages) of utilities regarding consideration of SPS as a power plant option in the 1990 time frame are summarized in Table 2-19.

Sixty-nine utilities spread throughout thirty-seven states expressed a positive interest in considering the SPS as a power plant option in the 1990-time frame.

Positive and negative purchase consideration responses from utilities by state are shown in Table 2-20.

Influence Values, Industrial-Utility Firms - The relative influence values of several factors affecting SPS purchase consideration by industrial and utility firms are shown in Figure 2-20.

In this comparison, utility and industrial firms rated demonstrations, low interest loans, land costs, and sale/exchange of excess power at almost the same values. Ratings by industrial firms of tax credits and accelerated depreciation factors at higher levels than those assigned by utility firms reflect basic differences in the way these two market sectors view these factors, i.e., tax credits provide industrials two-fold benefit in that the credit serves to reduce the effective purchase price and the firm is also permitted to depreciate the entire gross purchase

TABLE 2-19

UTILITY SPS PURCHASE CONSIDERATION
IN 1990-TIME FRAME

	No	%	Yes	%
Rural Electric Cooperatives				
- Generation systems	1		2	
- Transmission & Distribution System	21		9	
Total REC's	22	67	11	33
Municipally Owned Systems				
- Generation Systems	8		12	
- Transmission & Distribution System	13		27	
Total Municipals	22	36	39	64
Investor-Owned Utilities				
- Generation Systems	11		19	
- Transmission & Distribution System	3		0	
Total Investor-Owned	14	42	19	58
Total Responses	58	45.7%	69	53.5%

TABLE 2-20

SPS UTILITY PURCHASE CONSIDERATIONS BY STATE

	NO	YES		NO	YES
Massachusetts	1	0	Georgia	1	2
Connecticut	0	1	Tennessee	2	0
New York	1	0	Alabama	0	1
New Jersey	1	0	Arkansas	0	2
Pennsylvania	2	3	Louisiana	3	0
Ohio	3	1	Oklahoma	0	3
Indiana	2	0	Texas	4	9
Illinois	1	0	Montana	1	0
Michigan	1	4	Wyoming	0	1
Wisconsin	1	1	Colorado	4	5
Minnesota	3	2	New Mexico	1	2
Iowa	3	6	Arizona	1	3
Missouri	2	3	Utah	1	2
North Dakota	1	2	Nevada	0	1
South Dakota	2	2	Washington	1	0
Nebrasks	3	2	Oregon	1	2
Kansas	5	5	California	4	2
Maryland	1	1	Alaska	1	0
South Carolina	1	1			

ORIGINAL PAGE IS
OF POOR QUALITY

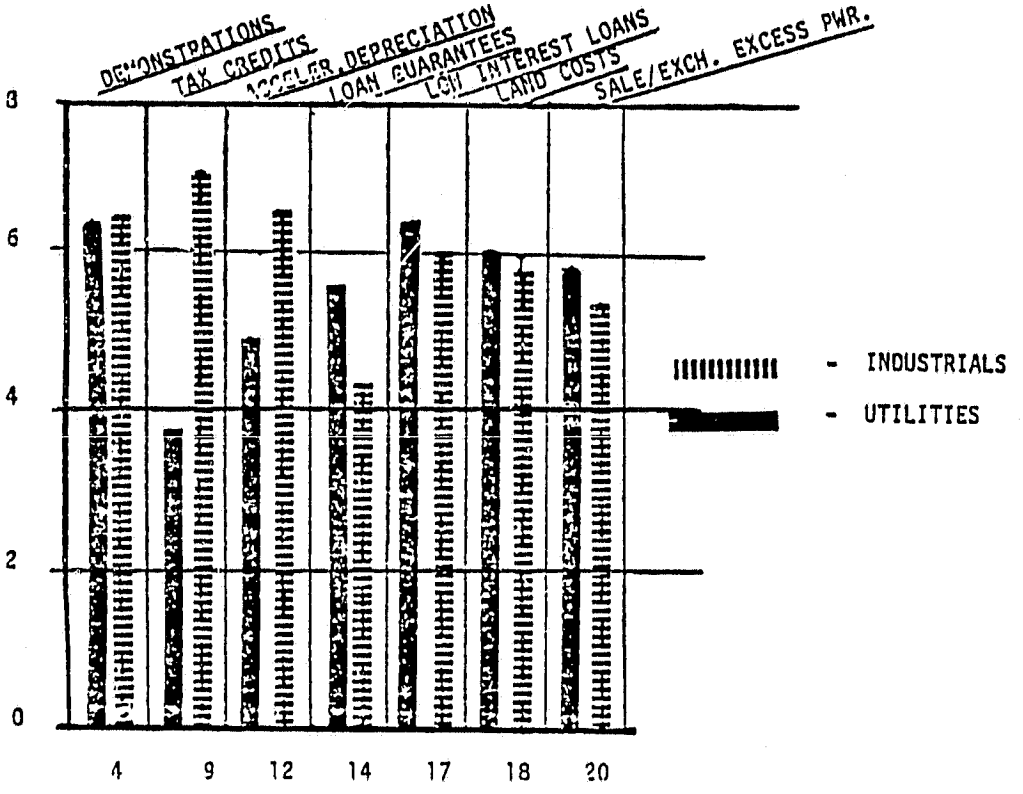


Figure 2-20. SPS Factors, Relative Importance to Industrial and Electric Utility Firms

price. The lower rating given by utilities to tax credits reflects the fact that many non-tax paying rural electric cooperatives and municipal systems were included in the study.

The slightly higher rating of loan guarantees by utilities probably reflects responses from rural electric cooperatives whose loans are typically guaranteed. Also the types of industrial firms participated in the study would neither require nor desire a guaranteed loan if they planned to purchase the SPS. Any industrial firm which would require a loan guarantee would probably lack the financial resources to consider purchase of the SPS.

Utility Land Costs - Land cost estimates supplied by utility respondents were significantly lower than those of industrial respondents. The primary reason is probably the SPS siting flexibility of the utility networks as compared to an industrial plant. Solar Power Systems need only be along or near transmission lines in the utility system. The wide area range that even a small utility system encompasses makes it relatively easy to find suitable, inexpensive land for SPS installations.

The mean utility land cost from the 125 respondents was about $8500 per acre versus $20,000 per acre for the industrials. More significant was the median value of only $2000 per acre as compared to $10,000 per acre for the industrials. This means that at a given allowable land cost, a much higher percentage of utilities have land available to them then do industrial plants. For example, at $2000 per acre, 51% of the utility sector had land available, but only 23% of industrials, at $10,000 per acre, 71% of utilities versus 42% of industrials and at $10,000 per acre 85% of utilities versus 54% of industrials. Cumulative distributions of utility land costs and, for comparison, industrial costs are shown in Figure 2-21.

Disaggregation of land costs to various utility types was inconclusive. Investor owned systems had a slightly higher mean

ORIGINAL PAGE IS
OF POOR QUALITY

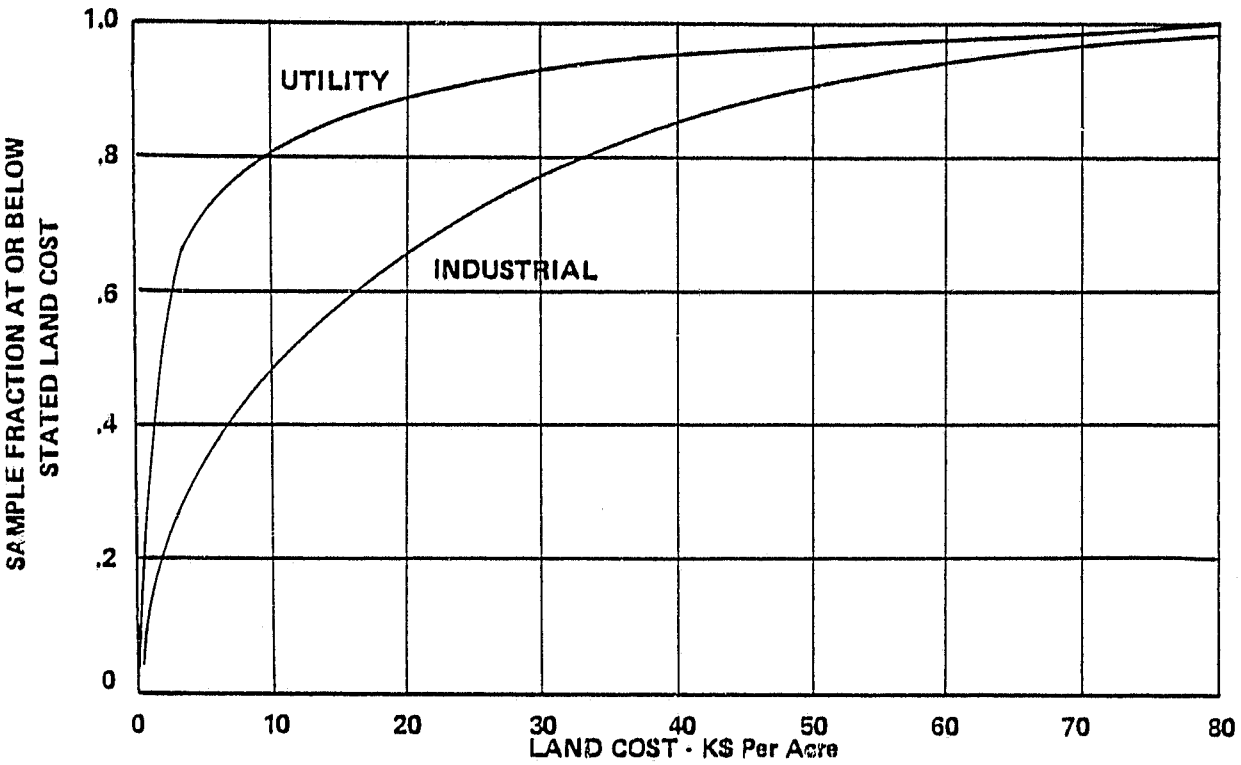


Figure 2-21. Utility and Industrial Land Cost Cumulative Distribution

cost $11,000/acre) but median cost of $2000/acre was identical to all utility respondents. Municipal utilities showed a slight increase in median land cost, to $3000 per acre.

Utility Financial Criteria - Financial investment criteria were supplied by 20 responding investor-owned utilities (IOU). Again, the lower response rate as compared to, for example, land cost responses, was most likely due to the aiming of the survey at energy rather than financial personnel. Although some responses gave a required return on investment, the large majority specified a Fixed Charge Rate (FCR). The FCR represents the percent of generation equipment capital cost that must be generated each year in revenue (before tax) to pay all the costs associated with owning the generation equipment. These costs include debt interest and principal, equity return, Federal and state corporate income taxes, local property taxes and insurance. Figure 2-22 presents the distribution of Fixed Charge Rates for the responding IOU's. Rates varied from 14 to 21% with the majority at 18%. The latter value is frequently cited or recommended by industry groups such as the Electric Power Research Institute (EPRI) for use in generation planning studies. All investor-owned utilities have similar debt-equity capital structures, cost of capital and Federal tax rates, and therefore similar fixed charge rates. State and local taxes vary somewhat, but are typically at a level that does not strongly affect the fixed charge rate (Consolidated Edison in New York City being a notable exception). Accelerated depreciation is widely used.

Municipal and cooperative utilities specified a variety of investment criteria, many of which centered around adequate debt interest coverage, rather than rate of return. Table 2-21 presents a summary of the various utility investment criteria.

Insolation Effects - Electric utility generation capacity is heavily concentrated in regions of moderate solar insolation.

OF POOR QUALITY

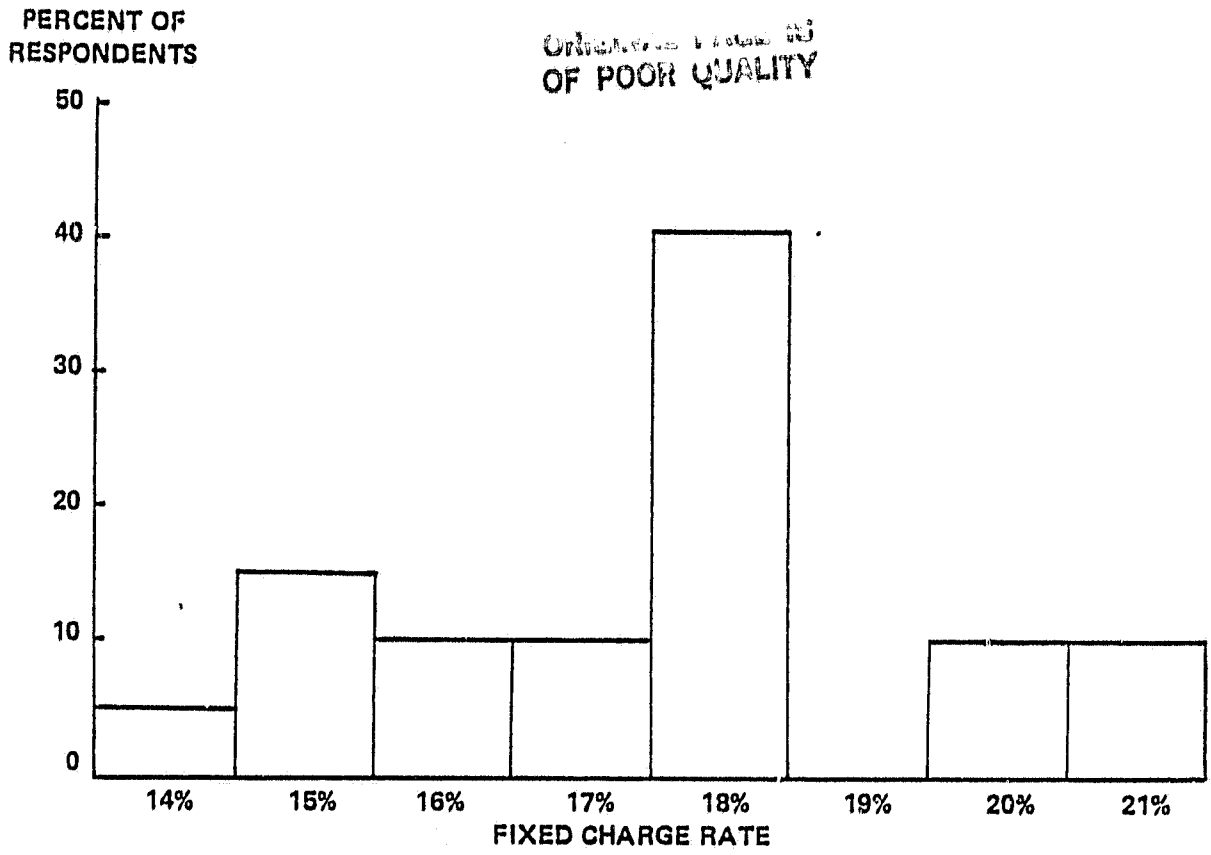


Figure 2-22. Fixed Charge Rate Distribution Investor-Owned Utilities

TABLE 2-21

UTILITY INVESTMENT CRITERIA

INVESTOR OWNED

- FIXED CHARGE RATE 14–21%, MEAN 17.7%
- RETURN ON INVESTMENT 9-1/2–20%, MEAN 12.2%

MUNCIPAL

- FIXED CHARGE RATE 11–14%
- BOND COVERAGE MORE IMPORTANT

COOPERATIVES

- RETURN ON INVESTMENT, 6–15% MEAN 10.4%
- OTHER
 - NET PROFIT = 1.2 (MIN) TO 1.5 (AVG) TIMES DEBT SERVICE
 - DEBT SERVICE RATIO ≃ 4.5

Figure 2-23 shows the distribution of utility fossil fuel capacity versus average daily direct insolation. About 50% of the capacity lies in states with daily average insolation levels of 3.6 - 4.0 KWH/M^2. Utilities will require solar power systems performing at lower insolation levels if substantial penetration is to be accomplished.

Combined Effects of Land Cost and Insolation Level - As was the case for the industrial sector, mean delivered or bus-bar energy cost for the utility sector is more than twice the level for the best solar regions. This is shown, for investor-owned utilities, in figure 2-24, which assumes SPS cost of $600/KW, at 5 acres/MW and 40% capacity factor in the best solar state (Arisona). At these values, bus-bar cost is on the order of 3¢/KWH in Arisona, with a national mean of 5.6¢/KWH. Municipal and cooperative utilities have a bus-bar cost roughly 2/3 of that for the IOC's based on survey data. This results from the lower effective fixed charge rate due to the absence of Federal corporation taxes.

Table 2-22 compares mean survey data on land costs and investment criteria and their corresponding effects on delivered energy costs. The primary difference is in the investment criteria, with the utility sector far more likely to plan over a long horizon as they approach true life cycle costing.

2.4.3 ENGINEERING DESIGN FIRMS

In order to obtain the views and reactions to the SPS from firms without direct financial interests in solar power systems, but who are nonetheless knowledgeable about power plants, seventy design engineering firms were selected for inclusion in the market analysis task. Firms were selected which traditionally have been major designers of power plants for industrial and electric utility applications. A nationwide listing of design firms, architect engineers, design engineering and construction forms was used to

ORIGINAL PAGE IS
OF POOR QUALITY

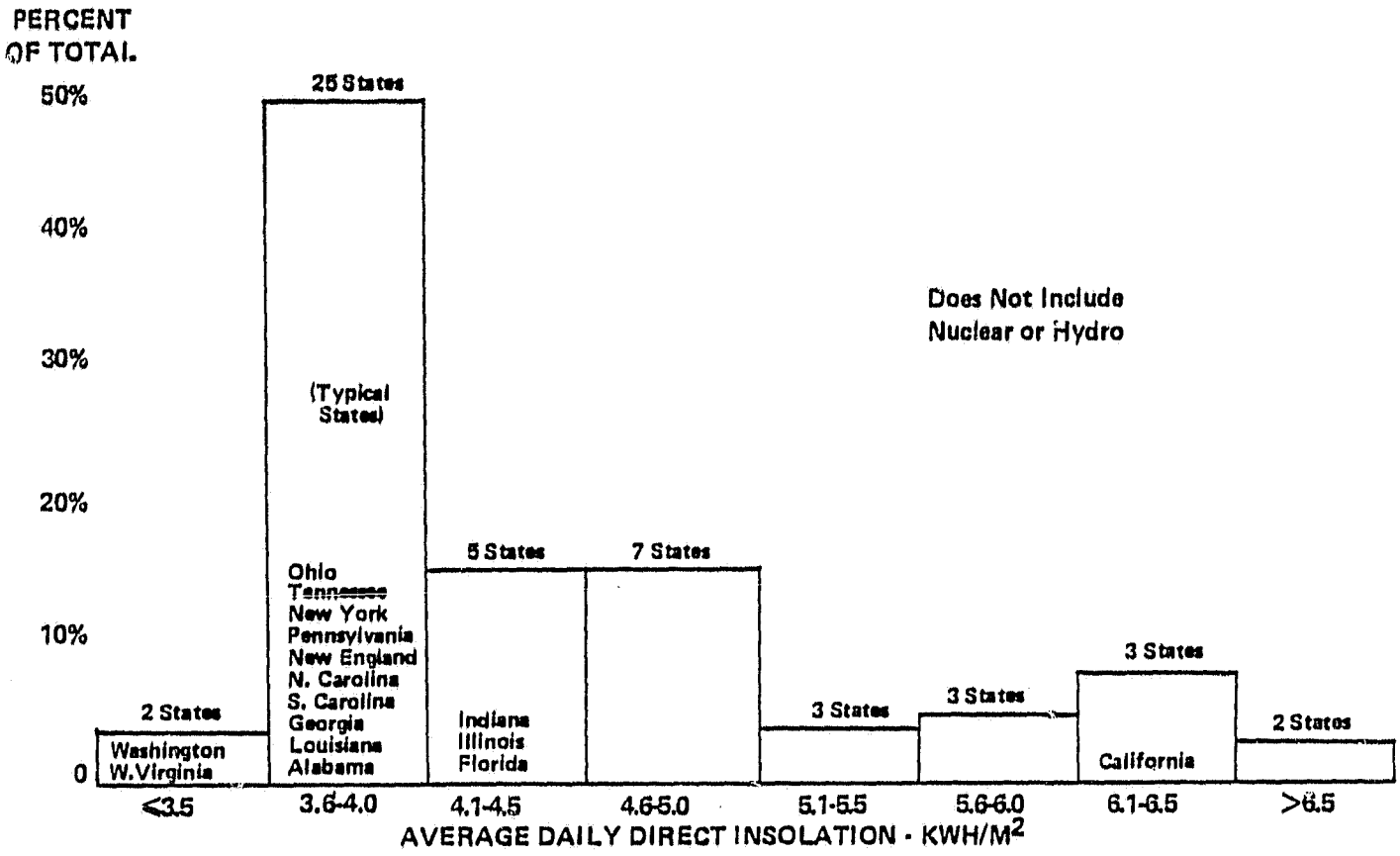


Figure 2-23. Distribution of Utility Capacity by Solar Region

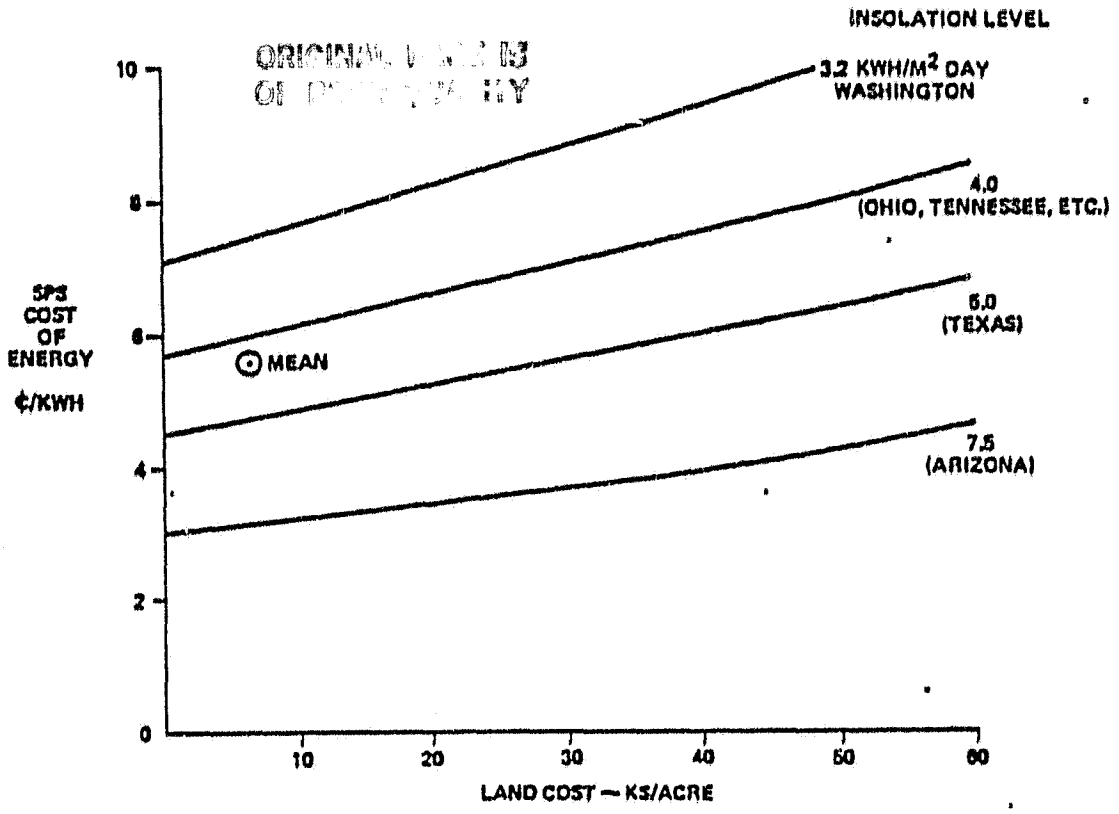


Figure 2-24. Effect of Land Cost and Insolation Level On Utility Cost of Energy From Solar Power System

TABLE 2-22

COMPARISON OF MEAN SURVEY RESULTS AND EFFECT ON ENERGY COST

	Industrial	Utility (investor owned)
Return on Investment	19.3%	-
Fixed Charge Rate	34.1% (equivalent)	17.6%
Cost of Land	$20,000/Acre	$8500/Acre
Weighted Mean Insolation	4.1 KWH/M^2 Day	4.3 KWH/M^2 Day
Cost of Electricity	12.5¢/KWH	5.6¢/KWH
Assumptions	600 $/KW System Cost 5 ACRES/MW @ 1 = 7.5 KWH/M^2/Day 40% Capacity Factor	

select the sample of seventy firms to be contacted. Firms with both domestic and international experience were identified and included in the market survey. A special set of questions and SPS descriptive material was prepared for use in this activity. Responses from approximately fifty firms were received, and the data provided was evaluated. The results of this evaluation follow.

Important SPS characteristics perceived by study participants were ranked in accordance with the significance attached to each factor. The relative importance of these SPS characteristics is shown in Table 2-23.

TABLE 2-23

IMPORTANT SPS CHARACTERISTICS
IDENTIFIED BY DESIGN/ENGINEERING FIRMS

Characteristic	Relative Importance
Energy Cost Savings	79%
Energy Curtailment Protection	68%
Ability to Fossil Fire	63%
System Modularity	47%
Pollution Reduction	45%
Availability of Process Steam	32%
Others Mentioned: • Fuel Independence • Public Image • Business Continuation	

Cost savings were the most important characteristic discerned by the respondents and were twice as important as the availability of process steam. While all of the factors listed are important, it is clear that the driving force is economic in nature, paral-

leling similar findings in the industrial and electric utility market sectors studies independently. Respondents were asked to identify any SPS drawbacks which they felt would impede market acceptance. These are summarized in Table 2-24 and are listed in accordance with the relative importance attached by these design engineering firms.

TABLE 2-24

SPS DRAWBACKS PERCEIVED BY DESIGN FIRMS

Characteristic	Relative Importance
Initial Cost	89%
Sun Variability	61%
Land Requirements	50%
Technical Complexity	32%

Others Mentioned:
- Maintainability
- Reliability
- "Government Red Tape"

It is interesting to note that land requirements for the system were third in relative importance, as contrasted with the much higher significance attached by industrial and electric utility firms to this same factor. The difference in relative significance can be possibly attributed to the fact that design/engineering firms are somewhat isolated from problems of land cost and availability. These firms attached a higher importance to the SPS's technical complexity that did a large percentage of other participants. This may be a reflection of power plant design experience and know how, coupled with the additional technical details furnished and a more immediate recognition or system complexities.

Since many of these respondents have been impacted by delays encountered in construction and licensing of new power plants, government regulations were mentioned often and were cited as "red tape".

The study participants were asked to identify potential SPS applications, based upon their domestic and international experience in designing and constructing conventional power plants. No new or unique applications were identified which had not previously been cited by other study participants. The applications most often mentioned are summarized in Table 2-25.

TABLE 2-25

POTENTIAL SPS APPLICATION IDENTIFIED BY DESIGN FIRMS

- Combined Power and Process Steam (Cogeneration)
- Southern Climates with Low Land Costs and Productivity
- Refrigeration
- Remote Applications Where Output Variability Not a Problem
- Medical Centers, College Campuses
- Summar Peaking Utilities
- Remote Military Installations

Design engineering firms were furnished more detailed technical information on SPS than was provided to industrial and electric utility firms participating in the mail survey. The level of detail given design engineers was comparable to that furnished to the GE field sales engineers for use in conducting personal interviews. Since these engineering firms often design power plants for utilities and industrials, this additional level of detail was considered appropriate. When asked to compare the central generation system with the distributed generation system concept, the engineering firms preferred the central generation concept by a margin of a two-to-one.

The SPS repowering option for existing steam generators was noted as a benefit of the central generation concept. However, the elimination of collector array piping and manifolding from the distributed generation systems was cited as offering lower field labor and installation costs, as well as offering the opportunity for more SPS factory assembly. This should result in lower costs and improvements in reliability and maintainability. The modularity of the distributed generation, permitting system greater size flexibility and ability to use noncontiguous land areas, were also recognized as benefits.

The concern about solar energy availability and variability was cause for a high degree of interest in fossil firing capability. The process steam output of the system was also seen as a valuable SPS feature. Table 2-26 provides quotes from typical responses comparing the central and distribured generation system.

TABLE 2-26

DESIGN FIRMS' VIEWS ON CENTRAL vs DISTRIBUTED GENERATION

Central Generation (Preferred)

- "More Flexible in Providing Various Energy forms"
- "Possible to Use Steam in Satellite* Industries"
- "Maintenance Capability In Place"
- "Adaptable to Present Power Plants"

Distributed Generation

- "More Flexible as to Size/Capacity"
- "Can Tailor to Requirements"
- "Can Continue Operation With Part of System Out"
- "Can Be Factory Manufactured - More Reliable and Maintenance Free"

*Satellite means adjacent, but separate industrial plants.

Results were somewhat disappointing regarding design firm data and views for SPS market potential in the international market. Table 2-27 summarizes typical comments received on international market characteristics.

TABLE 2-27

INTERNATIONAL MARAKET CHARACTERISTICS AFFECTING SPS APPLICATIONS

- Land Cheaper and More Available Except in Densely Populated Europe and Asia
- Energy Prices Higher - More Dependence on Imports
- More SPS Acceptance Likely Than in USA
- Cogeneration Widely Used in Northern Europe
- Developing Nations Seem to Want What U.S. Has - Central Power Systems

While largely subjective, the general comments typically received from the design engineering firms are of interest. Table 2-28 summarizes the most frequently mentioned statements.

TABLE 2-28

DESIGN FIRMS' GENERAL COMMENTS ON SPS

- "Output Variability Major Drawback"
- "Looks Wildly Expensive"
- "Particularly Liked Fossil Backup and Process Steam Options"
- "Economics Would Preclude Such a Huge Expenditure"
- "Key Factor - Land Availability and Price"
- "Must Have Thermal Output or Photovoltaics are Better"
- "Users Must Realize Cheap Reliable Energy, Not Tax Credits and Government Subsidies"
- "Central Generation System Could Be Backed By Geothermal"
- "Low Interest if Government Involved"

These comments were freely offered by participants and probably are a good indication of an SPS educational process required with power plant designers to help alleviate some of their concerns. An understanding of these solar systems will be required by design firms called upon by industrial and electric utility clients to design future power plants.

2.5 ISSUES AND TRENDS

During the performance of the market analysis task, a number of issues and trends were identified in the industrial and utility market sectors studied. These factors are reviewed and discussed in this section. Some may impact the ultimate ability to achieve commercialization of the SPS, since they represent factors associated with SPS market demand and penetration.

2.5.1 ISSUES

Future Energy Demands - The single major issue, recurring throughout the market study, centered on the problem of meeting future energy demands. Utilities have experienced a period in which longer plant lead times due to regulatory constraints, high financing costs and increased pollution control requirements have severely limited this generation expansion flexibility. The Three Mile Island incident and the resulting impact on the nuclear power option have further aggravated this situation. Non-generating utilities are experiencing huge cost increases as power contracts are renewed, with many facing serious decisions regarding their future. Industrial respondents were not as concerned about power availability, feeling perhaps that power would be available at some price, which could then be reflected in product selling price.

System Capital Cost and Land Requirements - The role of SPS in meeting future demands brought forth two principal issues con-

cerning the system - capital cost and land requirements. The capital intensity, that is the high initial system costs and the land requirements, of SPS were major concerns to study respondents.

Although JPL price goals expected with high volume production were used in determining initial system costs given to participants in the market survey, a high percentage felt that the initial cost of the system was a major drawback. These systems will be competing with technically mature power generation systems, such as gas or steam turbines, diesel generators, hydrosystems and possibly other alternate energy sources such as wind turbine generators, photovoltaics and geothermal systems. For the non-utility applications, the major source of competition will be the low priced power produced by utility systems. Competition for investment funds for additional plant, equipment, or facilities will also be present to limit funds available for SPS purchase. The capital intensive nature of SPS will limit sales to firms possessing adequate financial resources to make the substantial investments required for the system and its required collector field acreage.

A major issue influencing the market potential for SPS is land price and availability. At 10 acres per megawatt and land cost of $21,000 per acre (the average from industrial respondents), land alone adds $210 per kilawatt to installed SPS cost. At the high end of reported land costs, $100,000 per acre, the increment is $1000 per KW. Utilities indicated considerably lower costs, with national averages on the order of $8000 per acre.

Other Issues - Almost as important, in many cases, was the need for demonstrated SPS performance and reliability in the user environment. Reactions was generally negative concerning government involvement, with the extreme position that the respondents had no interest in SPS if the government was involved.

Additional issues raised were conservation programs, contractual relations with other utilities, system capacity factor, and incentive programs.

2.5.2 KEY FACTORS

Land Availability - The competition for alternate use of the land will further limit the amount of land readily available for SPS. Land removed from agricultural production and converted to an SPS installation loses income previously produced. The value of the SPS energy output will be measured against this loss in land productivity, thus compounding the land use question in agricultural areas of the country. In some areas sufficient acreage is unavailable at almost any price for SPS applications, e.g., highly industralized Northeast urban area, the Los Angeles basin, automotive manufacturing centers in Michigan, and similar urban industrial locations. In these cases, even if the SPS were free, no market potential could exist.

Some respondents stated that land would not present a problem since the nature of their business required large buffer zones around the plant and many acres have been acquired for this purpose. Some of the chemical industries are characterized by this practice. On the other hand, many of the steel firms responding stated that land was a particularly severe problem for their locations since the manufacturing facilities were now occupying or planned to occupy all available land within the confines of the plant's boundaries. One of the steel firms stated that their land has been filled in from Lake Michigan and is extremely expensive. A firm in Texas stated that the Company owned over a million acres and that land would be no problem; however, this is the exception rather than the rule. To a vast majority of respondents, the land price and availability issues were viewed as major problems in the installation of an SPS of a sufficiently large enough generation capacity to be of value to the firm.

Performance and Reliability - Several years of operation of industrial and utility SPS demonstration plants will be required to prove the performance and reliability characteristics of these systems. both industrial and utility firms ranked the non-proven technology aspects of SPS as a major drawback to their consideration of these systems as a power plant option. Reliability and system performance must be carefully monitored and reported to alleviate concerns on the part of industrial and utilities about these two key factors.

As the Government selects demonstration sites for these systems, it is well to remember that there are industry and utility leaders which set the standards for other firms to follow. Without being too specific in this regard, there are leading firms in each of the major SIC categories that are viewed by the other firms of that classification as being the innovator or leader in developing and testing new technologies. Involvement of these firms and the dissemination of system performance results throughout the industry by these firms will have a great impact on the market acceptance of the SPS. Other members of the same SIC code have higher confidence in data published by the industry leader than they have in other sources of equally valid data. The same is true in the utility sector, in that there are firms which are recognized by other utilities of the same ownership classification as being the leader and the technical innovator for that particular market sector. Involvement of these utilities will also help accelerate market acceptance of SPS.

Contractual Obligations - This factor was cited in a number of cases as being an issue which would have to be resolved by the specific industrial or utility firm in considering purchase of an SPS. Many long-term contracts exist between industrial users and electric power suppliers, and among generation systems and transmission/distribution utilities. Some expect little or no problems with regard to future power contracts at favorable cost, whereas others expect severe problems.

Several steel companies responding exhibited the "no problem" characteristics. For a firm located in Iowa, the attractive power contract offered by the local utility was a major factor in the firm's decision to relocate to the particular city. This particular firm has a dependable, long term commitment at attractive utility rates and sees no need of alternate forms of energy in their future. The situation with some of the rural electric cooperatives responding is quite different, however. These organizations are facing expiring contracts with supplier utility firms and rate escalations which may dramatically affect their ability to remain in business. It is not inconceivable that some of these REAs will be forced to sell their transmission lines and distribution facilities to larger utilities under such circumstances.

Electrical Cost Increases - Among the RECs and municipals which presently generate power, the sharp increase in the price of fossil fuels has been reflected in greatly increased electric rates for their customers. As an example, in Texas there are seventy-five RECs serving 2.5 million customers via 750,000 connections through a system of 220,000 miles of lines which represent over 90% of the lines in the State. Electric bills doubled overnight in 1973 when Docket-500 of the Texas Public Utility Commission authorized deregulation of certain gas prices. The price of gas in some Texas localities increased by 700% over a three year period and by 1000% over a five year span. These price increases were directly reflected in consumer electric bills which double or triple those previously experienced. Texas RECs are ready to consider alternative power sources, including solar electric systems.

Rural electrical cooperative systems are owned and controlled by the customers to whom they provide service. Two basic types of rural electric systems exist, i.e., (1) distribution systems which retail power purchased from investor owned utilities, other rural electric power systems, and from Federal and other

public sources· and (2) generation and transmission (G&T) systems which produce and supply rural electric power.

Of the approximately one thousand rural electric cooperatives (REC) in the US, only forty-three are classified as G&T (generation and transmission) firms, and of these, only about two-thirds actually generate power. The balance of the Nation's RECs are in the business of distributing electric power to their customer-owners. In 1976, power generated by G&T's accounted for 28 percent of the power distributed by RECs, with the balance coming from other power companies and from Federal and other public power systems. However, there is a growing and widespread trend among RECs to generate a larger percentage of their power. These coops represent an increasingly important segment of the market for conventional power generation equipment. Prices paid by RECs and municipals for electric power from State or Federal sources, e.g., TVA, Bonneville Power Authority, and Power Authority of New York are reflecting the increased cost of larger percentages of nonhydro power produced by coal and nuclear generating facilities to meet increasing load demands. Rising prices for power produced by investor-owned utilities as part of the power mix supplied to RECs and municiapl systems are causing many transmission and distribution firms to seriously consider purchase of generating equipment.

RECs are joining together, and joining with municipally owned systems in a large number of joint ownership arrangements. The Public Power Magazine publishes an annual listing of all such joint activities. These actions are being inspired to a large extent by the need to form larger organizations which can justify purchase of generation equipment to meet their needs. In some cases, investor-owned utilities have sold excess generation equipment to such groups. These combined ventures can often achieve the economics of scale needed to justify purchase of larger capacity power generation equipment, e.g., coal or nuclear, or to purchase a share of large power plants.

Both RECs and municiaplly owned systems have access to lower interest loans than do their investor-owned counterparts. The essentially tax exempt status plus lower cost financing results in lower fixed charge rates for these two utility ownership classes than for investor-owned systems.

Also, as a general rule, RECs have available lower priced land than do most investor-owned utilities. The load growth of RECs was approximately ten percent per year for the 1975 to 1979 time period, based on data of the Edison Electric Institute. The availability of lower cost financing, less expensive land, system load growth requirements and the increasing trend toward more generation to offset rising power prices all work together to benefit the near term SPS market potential in these two sectors.

As contrasted with RECs, the annual load growth for investor-owned utilities (IOU) is sharply lower, 3-4%, again based on Edison Electric Institute data. Although there are exceptions, many investor owned utilities have excess generation capacity and the opportunity to sell new power generation equipment to this market sector is not as encouraging as in past years. The combination of high interest loans, higher priced land, lower load growth, excess capacity, and considerable uncertainty about future policies and regulations causes the early market potential for SPS to lag the REC and municipal market by several years. However, as projected by the SPS market demand model, the IOU market can be expected to eventually surpass the non-IOU market as this latter segment begins to peak out.

SECTION 3

SOLAR THERMAL POWER SYSTEMS DEMAND MODEL

Formulation of commercialization strategies for Solar Power Systems requires that high potential market sectors be identified. To assist in this task and to evaluate SPS market sensitivity to various influencing factors, an economic demand model was developed. The model, which draws heavily on interview and survey data, has been programmed for use on a time-sharing interactive computer terminal. A detailed description of the computer program appears in Appendix C. A schematic diagram of the Small Power Systems (SPS) demand model is shown in Figure 3-1. Principal user inputs to the model include:

1. Year for which SPS market estimate is desired
2. SPS cost estimate at that time
3. SPS cost performance - electrical and thermal, including variation with insolation level
4. Either a future energy price scenario or, alternatively price escalation rates which the model can apply to current price levels.

Output of the model is an estimate of SPS total market at the year of interest and a breakdown by individual sectors - industry or utility type and state. Exercise of the model for a series of years and corresponding system costs will yield a market penetration scenario. Input parameters can be varied to test the sensitivity of each on the rate of SPS penetration.

Published data input to the model includes Edison Electric Institute data on energy prices and Census of Manufactures data on energy prices and energy consumption. The latter data was updated with the most recent Survey of Manufactures information.

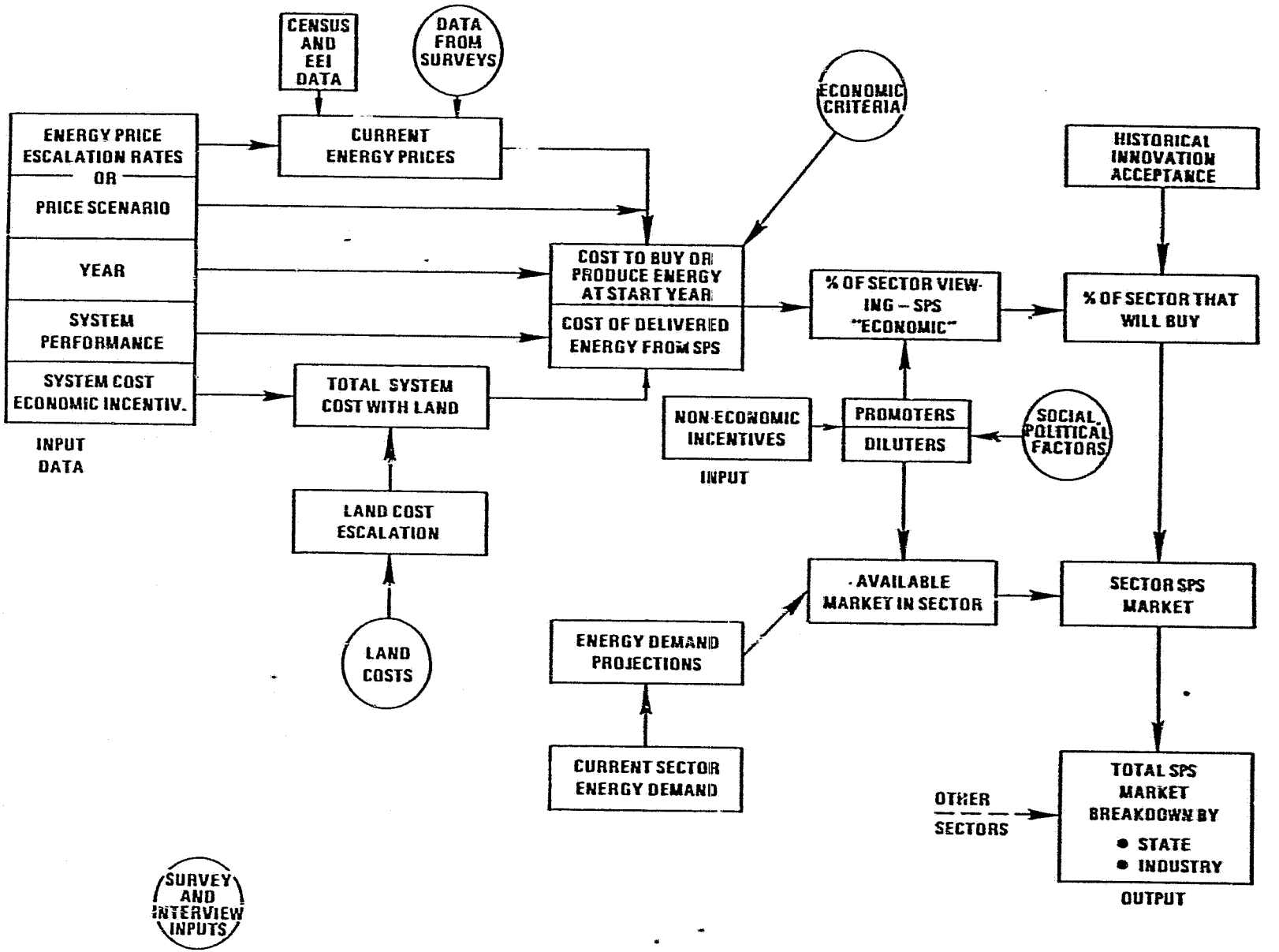


Figure 3-1. SPS Demand Model

ORIGINAL PAGE IS OF POOR QUALITY

SPS use by an industrial firm is assumed to save electricity at the average electricity (¢/KWH) for the appropriate SIC and state. For the electric utilities, it is assumed that fuel is displaced at the average cost of fuel per net kilowatt-hour, with no capacity credit taken.

Principal personal interview and mail survey inputs to the SPS demand model included:

1. Economic criteria applicable to investment in equipment such as SPS.
2. Land availability and cost.
3. Percent of sector who would consider SPS as a future energy option.

Economic criteria for the industrial study participants basically centered around return on investment, although many firms specified simple payback. For the utilities, Fixed Charge Rate (FCR) was commonly used and therefore employed in the demand model. The actual distributions of industrial Return on Investment (ROI) and utility Fixed Charge Rates from the interviews and surveys were input as tables to the demand model. Utility data was disaggregared to two categories -- investor-owned and others, which included municipals and rural electric cooperatives (REC). Disaggregation of industrial ROI to the various SIC codes proved inconclusive, therefore one ROI distribution was applied for all industrials.

Land cost distributions from the interview and survey responses were directly input to the model. Separate distributions have been used for the industrial and utility sectors. Disaggregation could not be accomplished to the individual SIC or state level, due to the limited size of the data base. There is evidence that significant differences may exist, with areas such as California and the Northeast reporting high land costs. Certain industries also showed high costs due to urban locations.

Each study participant was asked whether SPS would be considered as an option for his firm in the 1990-time frame. The answers provided input to the study as a form of market dilution. These are broken down by SIC or utility type. Where insufficient data exist for a particular sector, the overall average is used in the model. The demand model evaluates 24 user classifications in 50 states, for an upper limit of 1200 individual sectors. The user classifications include SIC codes 20 through 39, and the two principal utility ownership classes, investor-owned and non-investor owned, with the latter category limited to REC and municipal systems. A complete listing with the computer classification numbers is shown in Table 3-1.

Computation by the demand model follows the schematic of Figure 3-1. Within a sector, given land cost distribution and the input system cost, a total cost distribution is first computed. Energy price for the sector at the reference year is obtained either from the input price scenario or from current prices and the input escalation rates. The economic criteria from the interviews, based on energy price versus SPS performance and cost, is employed to determine what portion of the sector will view SPS as "economic" or cost-effective. Once economic viability is reached, SPS penetration rate is assumed to follow historical patterns typified by the Fisher-Pry substitution model*. The available

*The Fisher-Pry model is based on the relationship:

$$\ln\left(\frac{m}{L-m}\right) = c + \phi\,(t - t_1)$$

where: m = market share captured by innovation
c = constant
ϕ = a substitution rate coefficient
L = an upper limit on share

The model in effect states that market share captured by an innovation is proportional to the size of the market which is not yet captured, and that the growth rate of this relationship is constant over time.

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE 3-1

DEMAND MODEL CLASSIFICATIONS
20 - Food
21 - Tobacco
22 - Textiles
23 - Apparel
24 - Lumber, Wood Products
25 - Furniture
26 - Paper
27 - Printing, Publishing
28 - Chemicals
29 - Petroleum Refining
30 - Rubber
31 - Leather
32 - Stone, Clay, Glass
34 - Fabricated Metal Products
35 - Machinery
36 - Electronic Equipment
37 - Transportation Equipment
38 - Instruments
39 - Miscellaneous Manufacturing
43 - Ferrous Metals
53 - Non-Ferrous Metals
63 - Uncategorized Industries
83 - Investor Owned Utilities
93 - Other Utilities (RECs & Municipals)

market within a sector is calculated from current sector energy requirements and assumed future growth rates. Dilution factors based on user consideration, user economics and market penetration are applied to yield to estimatee SPS market for the sector at the particular point in time of interest. Combining all the sectors yields total SPS market.

The SPS model, as developed, is easily expandable to more user sectors and adaptable to more input data disaggregation. Constant energy price escalation rates have been employed for all sectors, but detailed price projections can be employed. Investment criteria and land cost can be disaggregated to the user sector, if sufficient data exists at some future time.

3.1 SPS DEMAND MODEL RESULTS

Numerous runs of the SPS demand model were made to determine early markets and required system costs to penetrate the markets. Figure 3-2 presents the market growth of a $1500/KW SPS, with energy prices escalating at 2% (over inflation) per year. The results are typical of all the runs. Note that the system costs here, and in subsequent figures, represent the total installed cost excluding land costs. The demand model factors in the land cost based on the actual statistical distributions acquired by the personal interviews and mail surveys. The early market is clearly the non-investor owned utilities which is comprised of Rural Electric Cooperatives (REC) and municipally-owned systems. As this market saturates, the investor-owned utilities (IOU) eventually see SPS as economic and become the largest ultimate market. The industrial market is negligible for this case.

The effect of system price on SPS market is shown in Figure 3-3 for a 1990 start, again assuming 2% energy price escalation. Again, as system price drops, the non-investor utilities are the early market, but are rapidly surpassed by the IOU's as

ORIGINAL PAGE IS
OF POOR QUALITY

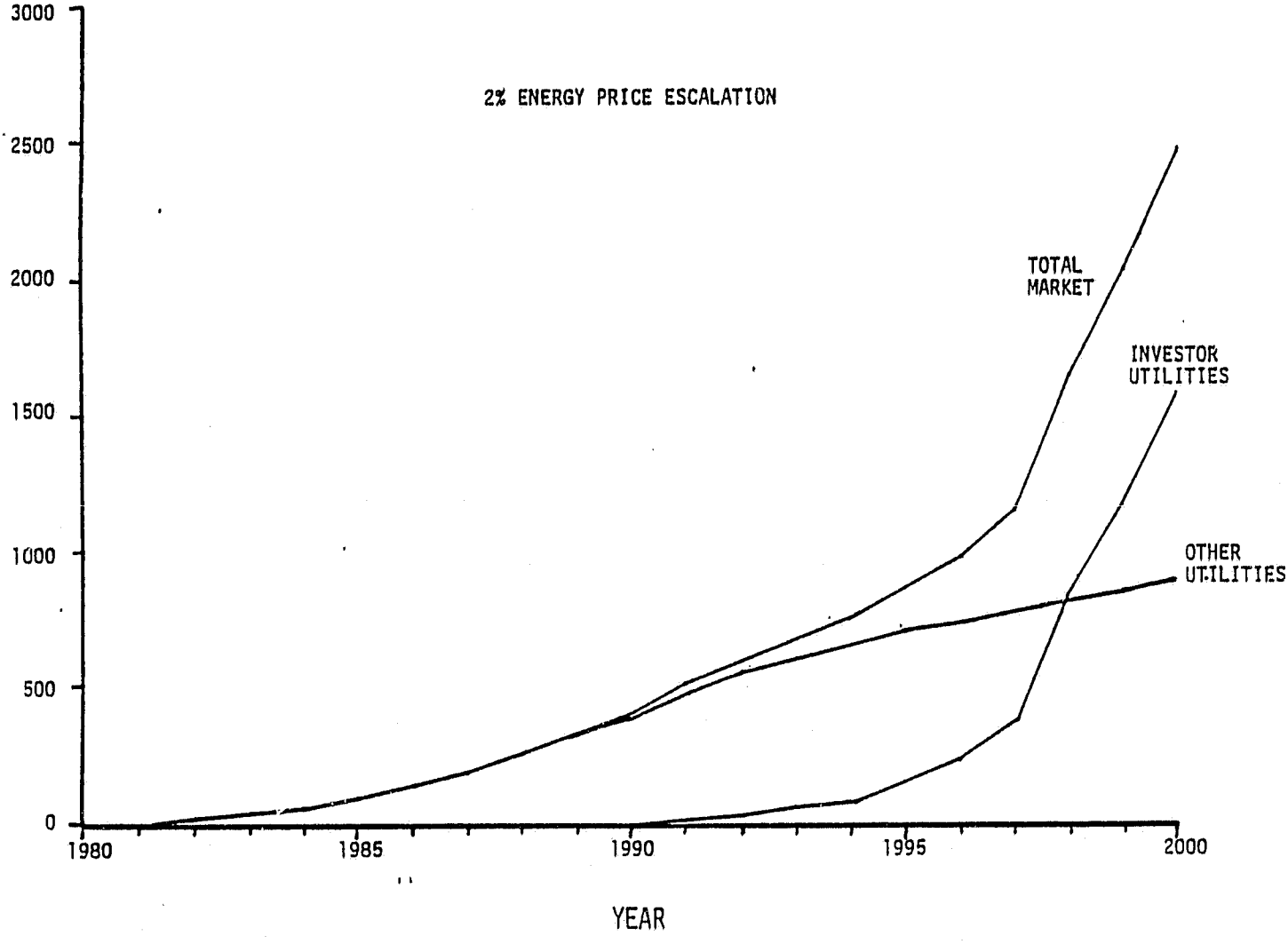


Figure 3-2. Projected SPS Market at $1500/KW (1980 $)

ORIGINAL PAGE IS
OF POOR QUALITY

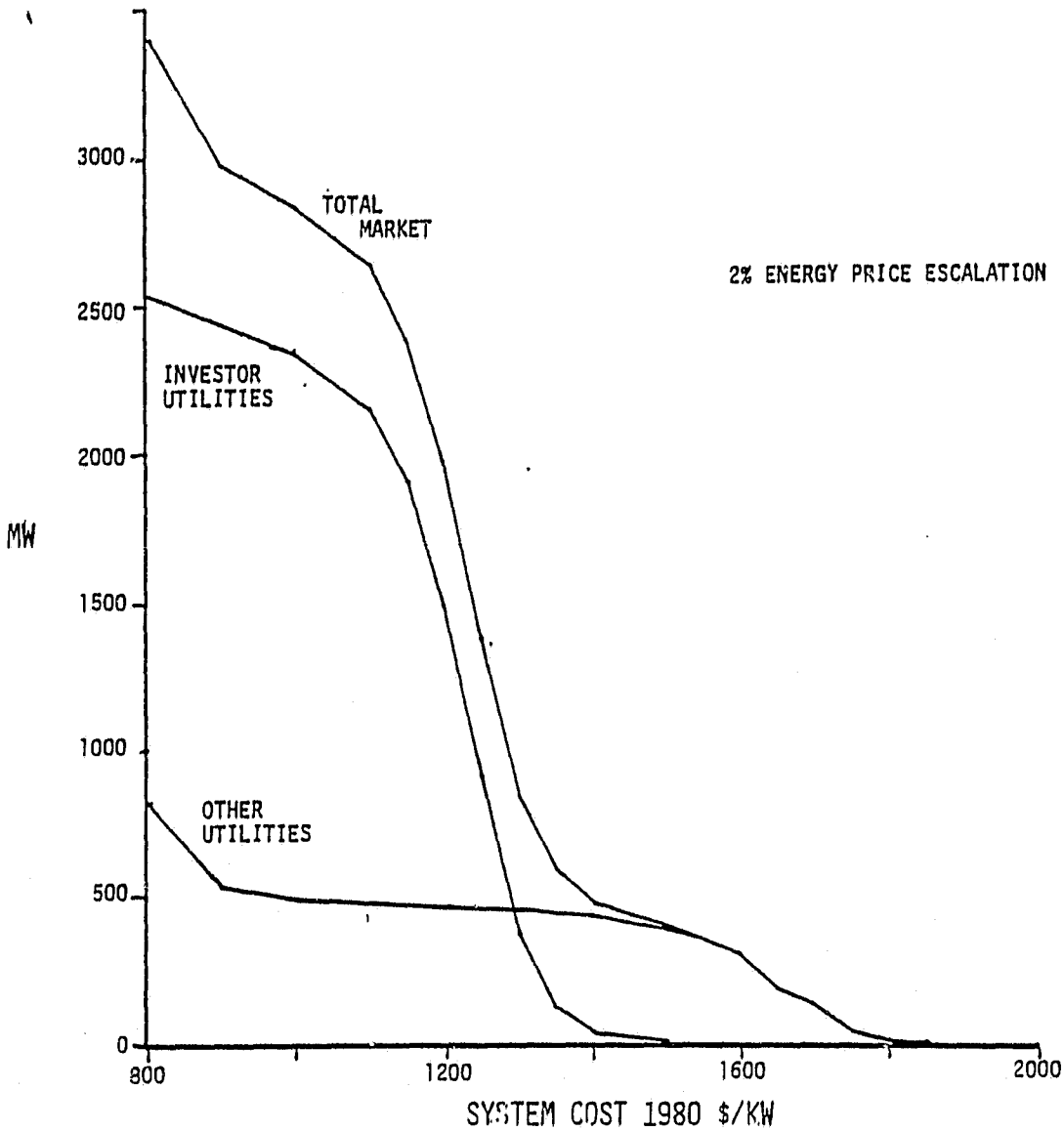


Figure 3-3. SPS Market in Year 1990 Versus System Cost

system costs drop below $1300/KW. Figures 3-2 and 3-3 present a repeated pattern of a substantial early market in the non-investor utility sector, followed eventually by a much larger market in the investor utilities. The effect of system cost on the non-investor utility market is shown in Figure 3-4. Cost reductions below $1500/KW did not show an appreciable effect on the near term (1985 to 1990) market in this sector.

Energy price increases have a major effect on SPS market potential, as is clearly shown in Figure 3-5. For a $1500/KW SPS, total market at the year 1990 is increased by about four times for 4% energy price escalation versus 2%. Note that by the year 2000, the market difference is less than three times. This is probably due to the 4% escalation rates resulting in early market saturation, with the 2% penetration rapidly increasing from about 1997 on. To put the absolute values of Figure 3-5 in perspective, the 1978 total generation capacity in the U.S. was about 600,000 megawatts. In the year 2000 the 4% point of Figure 3-5 is about 1% of this value, and substantially less than 1% for year 2000 installed capacity. The most extreme case runs in the study, a system cost of $800/KW with 4% energy price escalation, resulted in about 4.8% of total national generation capacity being SPS at the year 2000.

The SPS industrial market for electric-only SPS is significantly smaller than the utility market, due primarily to the higher rate of return required by the industrials. Figure 3-6 shows that, at 2% energy price escalation, system prices of $1100/KW or less are required for SPS industrial penetration. Even at $800/KW the industrial market is less than 350 MW by year 2000. Figure 3-7 shows the effect of 4% energy price escalation on the industrial market. Although total market is greatly increased for a given SPS cost, the cost required to achieve significant penetration is not greatly increased. The industrial market for electric-only SPS never exceeded 6% of the total SPS market, even at the most extreme points investigated. Cogenera-

ORIGINAL PAGE IS
OF POOR QUALITY

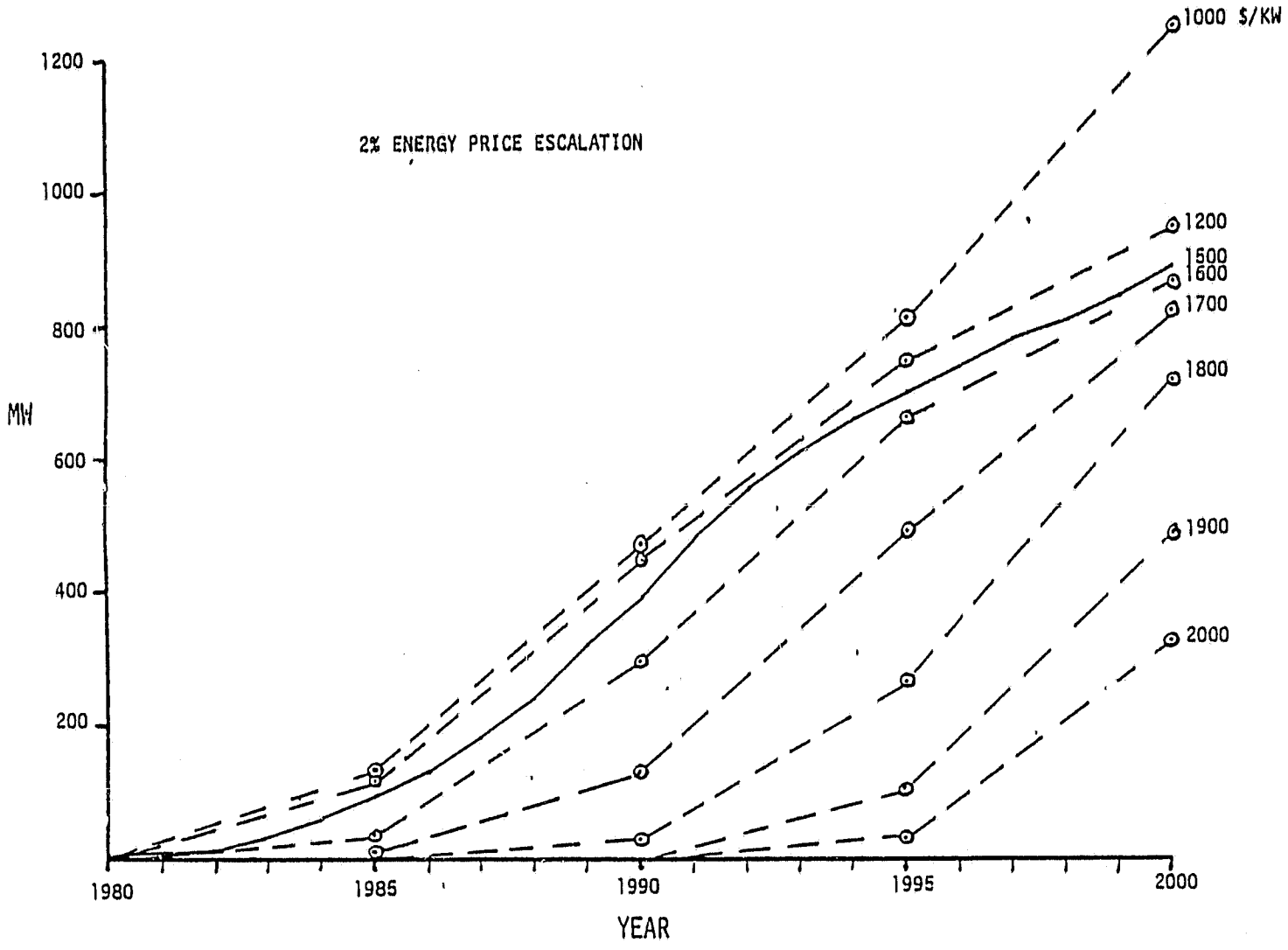


Figure 3-4. SPS Market in Non-Investor Utilities

ORIGINAL PAGE IS
OF POOR QUALITY

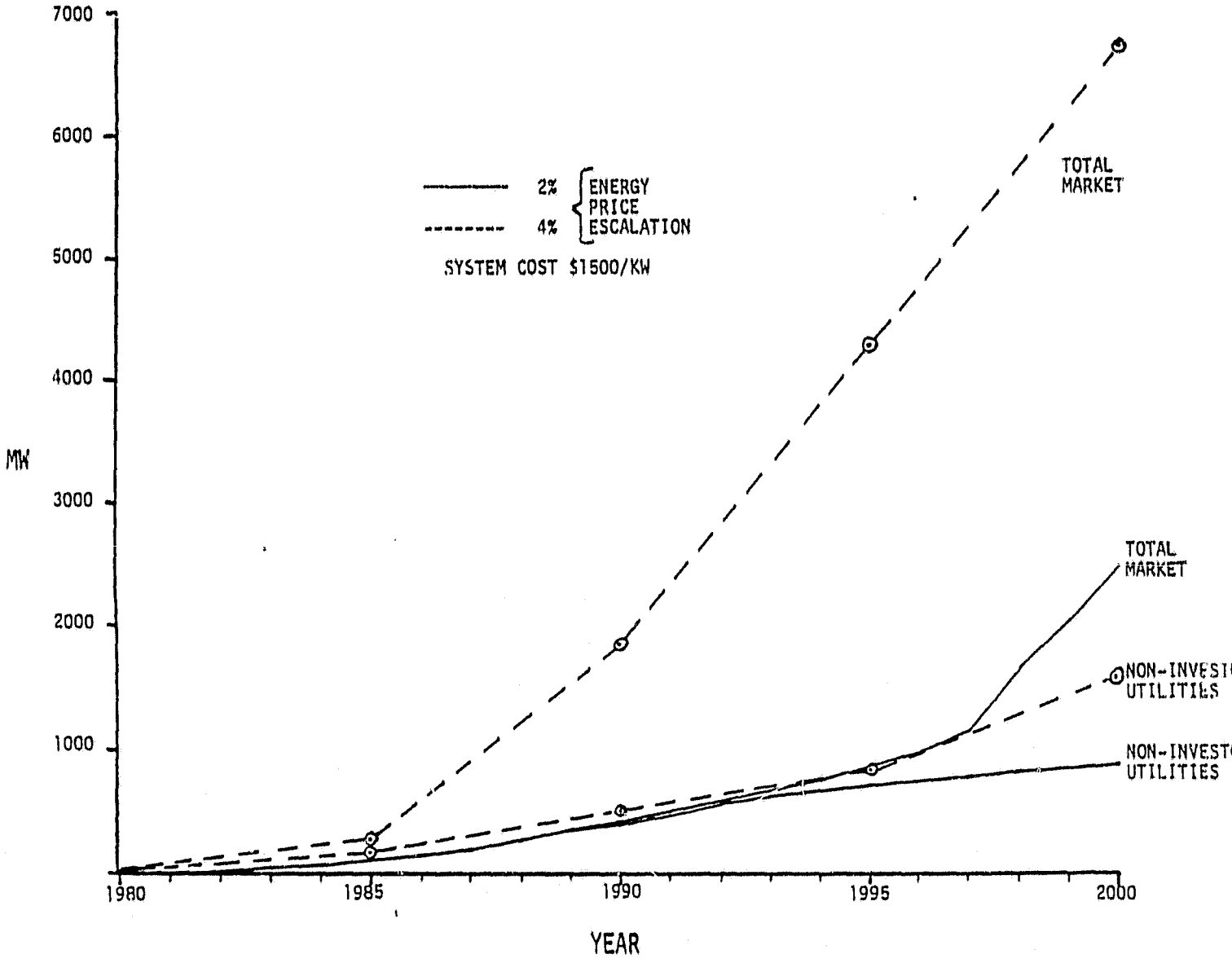


Figure 3-5. Effect of Energy Price Escalation on SPS Market

ORIGINAL PAGE IS
OF POOR QUALITY

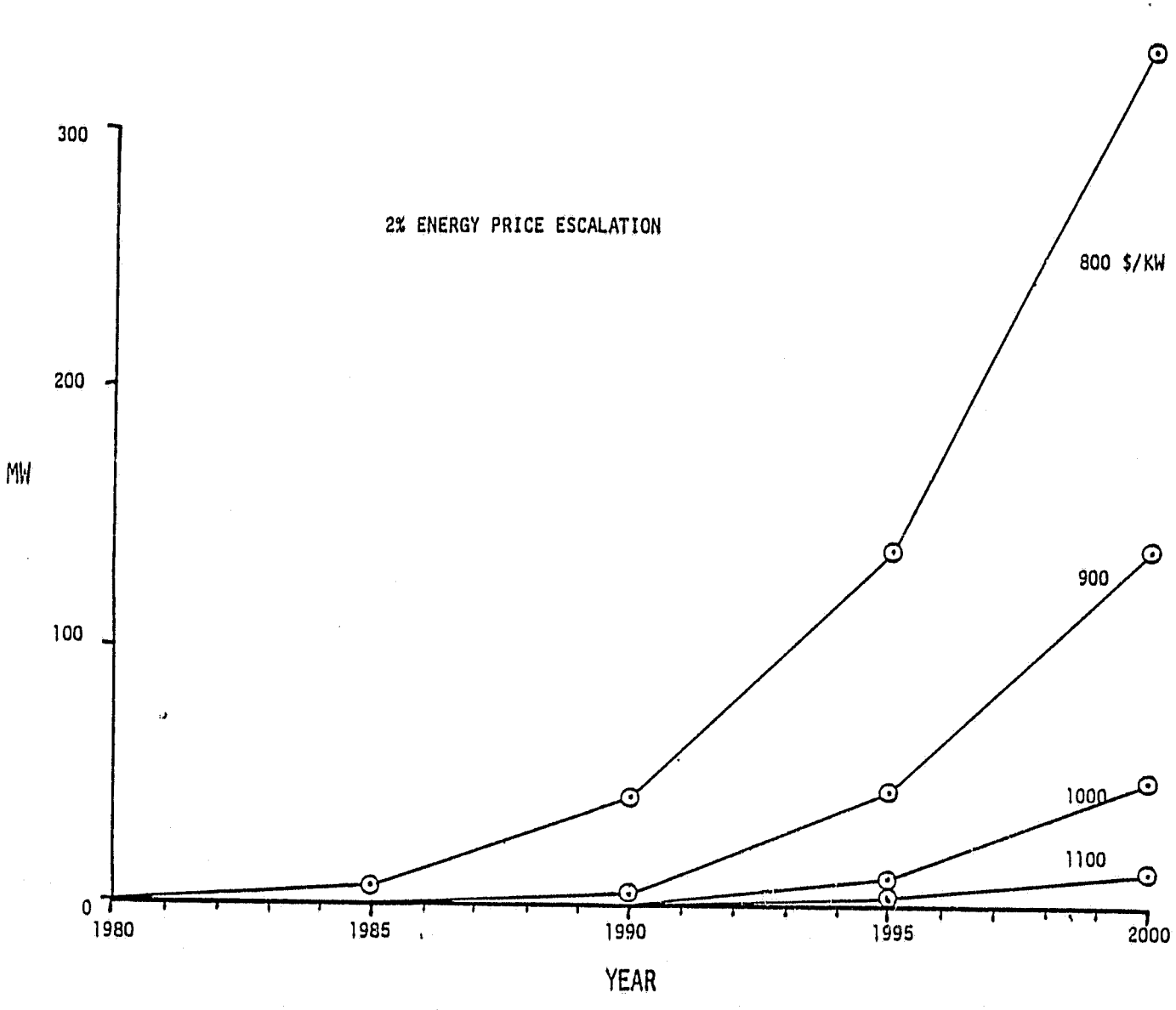


Figure 3-6. SPS Industrial Market Electricity Only

ORIGINAL PAGE IS
OF POOR QUALITY

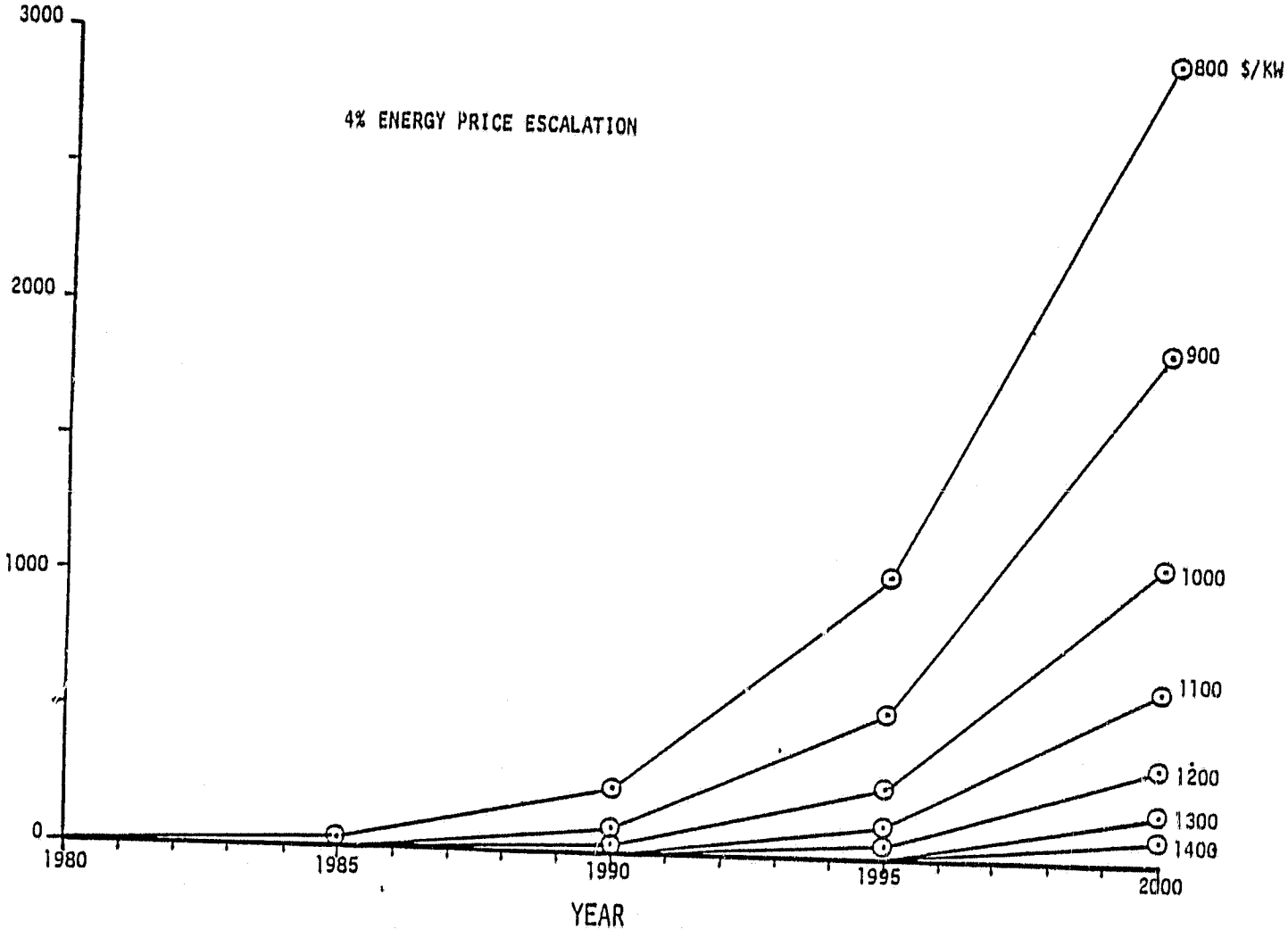


Figure 3-7. SPS Industrial Market Electricity Only

tion of electricity and process heat could present a quite different picture, however. Depending on operating temperatures and the relative prices of electricity and thermal energy, the output of a cogenerating SPS can be worth two to three times the value for electrical output alone*. Efficiency of the power conversion unit is less important, since inefficiency becomes usable thermal energy. By far the large majority of present industrial electric generation is cogeneration, with electricity actually being the by-product of a process heat requirement. A negative factor to SPS involvement in this market is the fact that systems typically run at very high load factors, with 7000 to 8000 hours per year operation not uncommon. SPS would thus either be "demoted" to a fuel saver for the conventional boiler or would require supplemental fossil firing to achieve the high load factors. The latter course may be attractive, particularly if the design concept is not "locked in" to premium fossil fuels - oil and natural gas. Figure 3-8 presents a range of potential SPS cogeneration market by the year 1990 for the five major cogenerating SIC's. Energy price escalation rate was again taken at 2% and system price varied. A market on the order of 100 MW is estimated for system costs in the $1400 to 41600/KW range.

3.2 CONCLUSIONS - DEMAND MODEL

Results of the demand model should be used to evaluate trends rather than absolute market value. The importance of the non-investor owned utilities to SPS market is clearly shown over a wide range of demand model runs. In addition to providing the early market, these utilities can also serve as SPS "demonstrators" for the investor-owned utilities and thus lay the groundwork for the huge ultimate market potential of this sector.

*Thermal energy is typically worth about 1/3 the value of electrical energy on a BTU basis (to some extent reflecting the efficiency of central station power plants). An SPS with an electrical efficiency of 25% will have 75% of the input energy available for thermal use. Multiplying by 1/3 to yield equivalent value shows thermal equal to electrical output in value. When boiler efficiencies and actual energy prices are taken into account the thermal value often exceeds the electrical by as much as a factor of 2.

ORIGINAL PAGE IS
OF POOR QUALITY

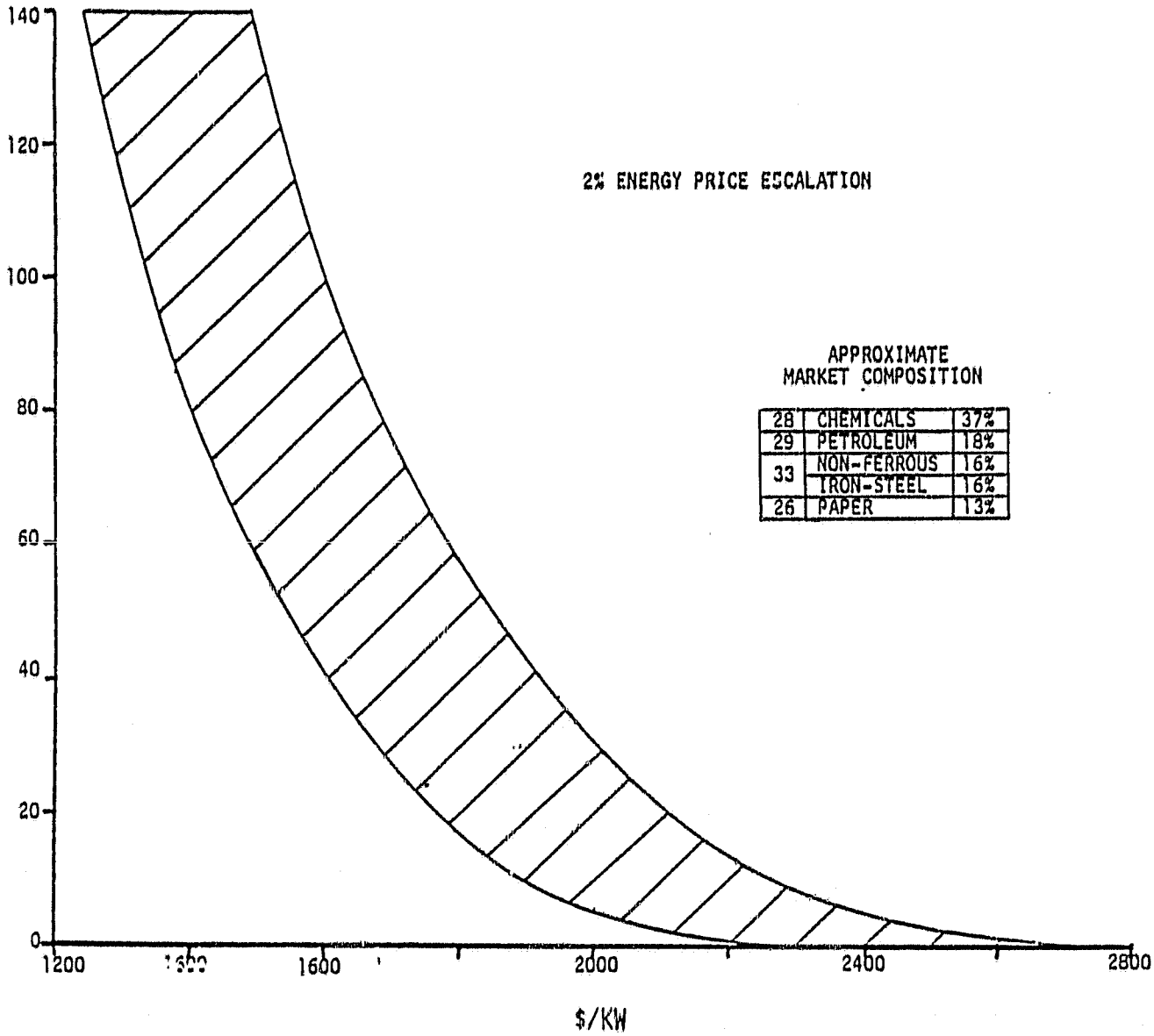


Figure 3-8. SPS Market Range for Industrial Cogeneration

The industrial market for electricity-only SPS is, by comparison to the utility markets, insignificant. In fact, it could easily be concluded that it will always be more cost effective, under current laws, for the utilities than for the industrials to purchase SPS. The lower utility cost of capital, even with administrative and overhead burdens added, will still yield lower priced electricity to the industrial than he can produce himself.

The exception to the above is cogeneration, where the industrial can effectively use the energy that, in a utility, is dissipated in a cooling tower. Cogeneration SPS applications must be rigorously evaluated however, to ascertain the true benefits of the SPS to the overall plant energy needs. Types of fuel currently used, fuel necessary for SPS fossil operation and required operational hours all are important. An industrial cogeneration market for SPS will undoubtedly evolve, but may require very specific conditions to be economic.

3.3 SAMPLE DEMAND MODEL RUNS

Included in this section is a sample set of SPS demand model output data. It is for a 1990 start, energy price escalation rate of 2% and system price of $800/KW. Market is shown by state and Standard Industrial Classification (SIC), with the latter slightly modified as shown in Table 3-1. Also shown is the percent penetration of SPS in the particular state and SIC and the current (in this case 1990) price of energy to that sector (in 1980 dollars). Following the state data a national breakdown by SIC tabulated.

ORIGINAL PAGE IS
OF POOR QUALITY

SPS MARKET STUDY

START YEAR 1990

SYSTEM COST 800 $/kW

PAGE 1 of 3

ELECTRICITY PRICE ESCALATION .02

FUEL PRICE ESCALATION .02

ST.	SIC	MKT (MWE)	% PEN.	CTS/KWH
ME	83	0.488E-01	0.0042	3.6503
VT	83	0.998E 01	6.4833	5.3506
VT	93	0.553E 01	6.9262	5.3506
MA	93	0.292E 01	0.5676	3.0107
RI	83	0.344E 01	0.9393	4.0714
CT	83	0.239E 00	0.0042	3.4631
CT	93	0.361E 01	4.9708	3.4631
NY	93	0.107E 02	0.8678	3.2135
NJ	24	0.513E-01	0.3890	9.2660
NJ	83	0.115E 01	0.0080	3.5255
NJ	93	0.816E 01	5.2027	3.5255
IN	31	0.314E-01	1.3512	9.5312
IL	93	0.179E 00	0.0148	2.5427
MI	93	0.120E-01	0.0007	2.6207
IA	93	0.281E 00	0.0266	2.2619
MO	22	0.237E-01	1.3940	7.5813
MO	25	0.165E-01	0.1093	6.8169
MO	31	0.395E-02	0.0159	6.4737
SD	27	0.530E-04	0.0033	6.3645
NB	23	0.167E-02	0.1093	6.1618
NB	93	0.105E 02	0.3510	2.1215
KS	24	0.534E-01	0.8490	6.8013
KS	34	0.632E-01	0.2526	6.3333
KS	93	0.241E 01	0.1388	2.0279
DE	23	0.454E-04	0.0033	8.4393
DE	93	0.211E 00	0.0867	2.9171
MD	93	0.592E-02	0.0173	2.9171
VA	93	0.343E-01	0.0523	3.0419
SC	93	0.842E-02	0.0004	2.4023
FL	93	0.151E 02	0.2201	2.8079
MS	93	0.254E 01	0.2428	2.6987
AR	83	0.115E 02	0.2628	3.2291
AR	93	0.303E 02	6.5621	3.2291
OK	93	0.980E 01	0.8560	2.2151
TX	93	0.459E 00	0.0039	2.0279
ID	83	0.487E 01	6.8360	3.8842
NM	20	0.2[illegible].E-01	0.1169	5.1790
NM	32	0.132E-01	0.0524	5.1322

C-2

ORIGINAL PAGE IS
OF POOR QUALITY

SPS MARKET STUDY

START YEAR 1990

SYSTEM COST 800 #/kW

PAGE 2 of 3

ELECTRICITY PRICE ESCALATION .02

FUEL PRICE ESCALATION .02

ST.	SIC	MKT (MWE)	% PEN.	CTS/KWH
AZ	20	0.107E 01	1.9624	5.5066
AZ	23	0.140E 00	1.4812	5.5846
AZ	24	0.815E-01	0.3383	4.7734
AZ	27	0.742E 00	4.9364	7.3473
AZ	29	0.199E-01	1.0820	5.7250
AZ	32	0.121E 01	1.8549	5.7718
AZ	34	0.129E 00	0.9065	5.1322
AZ	35	0.359E 00	0.8745	5.1010
AZ	37	0.669E 00	1.4592	5.3662
AZ	39	0.112E-01	0.2526	4.7266
AZ	83	0.547E-01	0.0013	1.7471
AZ	93	0.234E 03	4.1348	1.7471
NV	20	0.401E 00	3.0863	7.2381
NV	27	0.902E-01	1.5032	6.5049
NV	32	0.104E 01	2.2736	7.1913
NV	35	0.111E 00	6.6359	9.3596
NV	83	0.188E-01	0.0005	1.9655
OR	83	0.839E 02	6.1146	5.0854
OR	93	0.746E 01	6.8851	5.0854
CA	20	0.705E 00	0.0688	5.1322
CA	22	0.714E 00	1.0913	5.7250
CA	23	0.168E 01	1.8588	6.8013
CA	24	0.115E 00	0.0281	5.0230
CA	25	0.241E 00	0.2526	5.4598
CA	26	0.204E 00	0.0417	5.0854
CA	27	0.6[illegible]E 00	0.2526	5.4598
CA	28	0.600E 00	0.0648	5.1322
CA	30	0.168E 01	0.3890	5.5690
CA	31	0.269E-01	0.1612	5.3038
CA	33	0.136E 00	0.0174	4.9762
CA	34	0.499E 01	0.8490	5.3[illegible] 2
CA	35	0.140E 01	0.2526	5.45.8
CA	37	0.138E 02	1.4122	6.0994
CA	38	0.140E 01	0.[illegible]490	5.8342
CA	39	0.500E 00	0.0648	5.7250
[illegible]	43	0.[illegible]E 01	0.8196	5.[illegible]42
[illegible]	53	0.[illegible]E 01	0.8196	5.[illegible]42
CA	83	0.227E 04	7.[illegible]5	4.0714
CA	93	0.[illegible]E 03	7.[illegible]	4.0714
AL	93	0.[illegible]5E 01	0.[illegible]	3.3915

ORIGINAL PAGE IS
OF POOR QUALITY

SPS MARKET STUDY

START YEAR 1990

SYSTEM COST 800 $/kW

PAGE 3 of 3

ELECTRICITY PRICE ESCALATION .02

FUEL PRICE ESCALATION .02

ST.	SIC	MKT (MWE)	% PEN.	CTS/KWH
HI	20	0.112E 01	2.1280	6.8553
HI	26	0.541E-01	9.5509	11.4187
HI	32	0.419E 00	2.4347	7.1133
HI	33	0.139E 03	7.4526	3.6971

BREAKDOWN OF TOTAL MARKET (FOR ALL STATES) BY SICS

SIC	MKT (MWE)
20	0.333E 01
22	0.737E 00
23	0.183E 01
24	0.301E 00
25	0.857E 00
26	0.258E 00
27	0.147E 01
28	0.600E 00
29	0.199E-01
30	0.168E 01
31	0.622E-01
32	0.282E 01
34	0.518E 01
35	0.187E 01
37	0.145E 02
38	0.140E 01
39	0.511E 00
43	0.239E 01
50	0.227E 01
80	0.253E 04
93	0.824E 03

0.339996 57E 04= THE TOTAL MARKET (FOR ALL SICS & ALL STATES)

SECTION 4

COMMERCIALIZATION STRATEGIES

4.1 INTRODUCTION AND SUMMARY

This section discusses commercialization strategies which could help stimulate acceptance of Small Solar Thermal Power Systems (SPS) in those market sectors which have been identified as being the most promising for near-term applications. The market sectors include the non-investor-owned utility systems, followed later by investor-owned utilities, and subsequently by selected industrial applications for cogeneration.

Since the earliest commercial market potential exists with rural electric cooperative and municipally owned utility systems, Government efforts to achieve SPS commercialization should be focused primarily on this market. A long-range, strong Government policy in support of SPS is required to reduce investment risk and promote sales to this sector. For example, Government actions should include:

- Incentives such as grants or subsidies to users to reduce system price and investment risk
- Tax incentives for SPS manufactures or system assemblers
- Flexible cost sharing policy practices
 - Users
 - Producers
- Information dissemination programs
 - REC and Municipal Systems Owners
 - Financial Institutions
 - A/E Engineering design firms
 - Conventional power generation equipment

- Manufacturers and Marketing Firms
- Labor unions
- Trade Associations
- Technical Societies

• Continuing programs of SPS engineering experiments and demonstrations involving non-investor-owned utilities

Incentives which have the effect of reducing SPS costs to $1400 to $1500/KW, required for initial economic viability, are the major governmental actions required. Early markets will not be large enough to warrant investments in mass production equipment by the emerging SPS industry. Such equipment will be ultimately required to achieve cost reductions necessary to meet price goals needed for market penetration. Government incentives are necessary to reduce system costs. These incentives may need to be in the form of direct grants, subsidies or cost-sharing, since the REC and municipal systems would not benefit greatly from tax incentives due to their inherent non-tax or limited tax paying environments. Also, the ability to borrow funds at attractive rates reduces the value of low interest loans or loan guarantees to this market sector, except for transmission and distribution systems which desire to become power generators but whose prior investments have been less capital intensive in nature.

Other Governmental actions supportive of early development of this market include information dissemination programs directed at these non-investor-owned utilities and the financial institutions which now serve them. In addition, since the sales organizations which provide conventional equipment and services can be expected to help form the SPS industrial infrastructure, it is essential to include these organizations in the information program.

Government sponsorship of SPS engineering experiment demonstration projects is essential to stimulate system development

and to acquire operational experience and reliable system performance -- vital elements of early market acceptance. To the maximum extent possible, these should involve non-investor-owned utilities. These installations also will be of value toward establishing SPS experience applicable to the investor-owned utility sector.

Since industrial applications are not expected to emerge until much later and at much lower sales volume than the utility markets, this market sector need not receive early Government commercialization stimulation attention.

Cost-sharing policies directed toward SPS producers must be flexible; otherwise, they will be counter-productive to commercialization objectives. For example, if cost-sharing is mandated, prior investments in research and development, as well as plant and equipment, should receive favorable consideration for qualification; otherwise, industrial investments in these elements vital to SPS development may lose out to competing demands for corporate resources. Similarly, cost-sharing practices which do not allow a reasonable fee or profit on SPS sales diminish the attractiveness of participation in the marketplace. This is true, particularly if such participation requires resources for the development of the business, i.e., proposal and marketing expenses, R&D to achieve technological advances, plant and equipment (P&E) expenditures to produce the hardware.

4.2 GOVERNMENT POLICIES AND INCENTIVES

To help achieve National energy goals, Government policy is today encouraging commercialization of solar energy products. This environment for solar energy products can be compared to the Government's sponsorship of the nuclear power industry. Although the Government is encouraging solar commercialization, traditional decision-making processes of commercial enterprises will still be employed in reaching decisions to make required investments, take

appropriate risks, and bring together required resources necessary to introduce these new solar energy products to the commercial marketplace. However, the Government's participation is especially important in accelerating the development of these new products and establishing a business environment in which they can compete.

Many studies have been made on the subject of commercializing solar energy systems, with major emphasis on near-in applications, such as hot water, steam, and space heating. The main thrust of these studies has been establishment of a national industry. These are essential activities, sponsored by the Government and by private firms, which need to be continued. They will help assure that the solar technology being developed is properly oriented, and that mechanisms for usage of the technology exist.

Government sponsorship of research and development programs stimulates emerging industries as is being currently experienced by the solar energy industry. Also, a continuing program of Government sponsored research and development in support of SPS will act as a powerful market stimulation tool to encourage participation in this industry by qualified firms. The information dissemination program to be conducted by the Government, which will provide widespread knowledge regarding SPS, can also be an effective market stimulation technique.

Active encouragement by both industry and Government is required if commercialization is to be achieved. Currently, system prices are not competitive with competing energy sources. Market stimulation is required to promote the usage of these systems. The Government role can include such actions as sponsorship of the experiment and demonstration projects, procurement of systems for Government installations, a continuing Government-sponsored research and development program, and Government incentives for system producers and users.

Another key Government action to help stimulate the market involves information dissemination programs for SPS design and performance data. As part of the commercialization strategy, it is vital to understand the current legislative environment as it affects the prices to the consumer of solar energy projects, and to extrapolate this legislative environment into future potential effects on SPS pricing. For example, current legislative practices regarding grants and subsidies for purchase of solar collectors for use in domestic hot water or space heating applications have the effect of making the solar system a "loss leader", which is a traditional technique of building the market and encouraging entry into the market by new firms to help establish a new industry.

A long-range plan coupled with large Government commitments is necessary to bring about initial and continuing SPS market penetration. To achieve initial penetration by 1990, installed prices for SPS must be equivalent to $1500/KW for either the electric-only option (utilities) or the electric-thermal option (industrial applications). Since mass production equipment and sales volume needed to approach these prices will probably not be in place by this time, Government incentives in the forms of outright grants, investment tax credits, solar energy tax credits, refundable credits (rather than off-sets against profits), and others will be required to reduce the effective system prices to those required for market penetration. The ultimate ability to commercialize the SPS will be very heavily influenced by Government policies which provide incentives to purchasers of these systems and which remove the barriers which could preclude or forestall a prospective owner from making an investment in these systems. Anticipated Government policies must be factored into market forecasts and reflected in investment plans.

The future viability for SPS will be influenced by the cost effectiveness of these systems as a function of system costs when compared to the price of other energy sources. Historically, the Federal Government has enacted programs, which, in effect, subsi-

dized the production and distribution of conventional forms of energy. Such encouragement of solar energy is being enacted by various legislative bodies. These economic incentives will aid the growth of nearer-term solar energy markets and, in all probability, the future market for SPS. Types of incentives now under consideration are shown in Table 4-1.

TABLE 4-1

GOVERNMENT INCENTIVES UNDER CONSIDERATION

Type of Incentive	Purpose
Direct grants, income tax credits deductions, reimbursements	Reduction of initial cost
Loan guarantees, government insurance and reinsurance	Increase capital availability
Low-cost loans, tax-free bonds, costs accelerated depreciation and rapid amortization; state sales, use and property tax relief	Lower life-cycle costs
Demonstration programs, information dissemination, government procurement program, education and training programs, incentives for utilities	Market stimulation
Protective tariffs	Domestic production protection
Deregulation of fuel prices and/ tax on consumption	Improve solar competitive or position

4.2.1 DEMONSTRATION PROGRAMS

Many demonstrations of SPS plants with good performance are a prerequisite to achieving any degree of initial market penetration. Utility and industrial firms will not purchase unproven technology. It is important that these early demonstrations achieve the highest performance and reliability commensurate with the experimental or demonstration nature of the installation. Poor system performance or reliability in these initial systems

will create a major barrier to be overcome. For example, the early heat pumps marketed by the air conditioning industry were plagued with reliability and performance problems. These caused massive problems to the industry and only after years of effort was the market redeveloped and customer acceptance obtained. In contrast with the heat pump market, the Government will have a dominant role in helping promote early SPS installations. Working with industry to assure high quality systems, the SPS should be spared a similar experience by a restrained pilot market introduction of well-developed and proven systems, matured through a sequence of successful demonstrations.

Cost-sharing by participating utility and industrial firms will be expected by Government agencies sponsoring SPS demonstrations. A degree of flexibility in the amount and form of cost-sharing must be maintained so that prospective system users are not discouraged from participation.

4.2.2 SOLAR AND INVESTMENT TAX CREDITS

Investment and solar energy tax credits are viewed as an effective tool for accelerating commercialization of SPS. However, regulations governing the application of these credits must be sufficiently broad so that they do not actually become counter-productive; e.g., tax credits for installation of small-scale hydro systems have been offered for the purpose of stimulating business to survey potential sites for such systems. Since the tax credit drops as the size of the system increases, some business may install smaller capacity systems than the site can actually sustain, in order to get the higher tax credit. An alternate incentive, which might be more effective, would appear to be a credit or grant of say, $15 per barrel of oil that was displaced by the energy produced by the solar system. In this scheme of rewarding the firm for not consuming fossil fuel, it would be necessary to develop a set of conversion factors, which would be

applied to the SPS to determine the equivalent amount of fossil energy saved. The National Bureau of Standards might be called upon to generate such conversion factors. At the present time, consumption of fossil fuel or other forms of energy by industrial firms and other business entities is treated as an expense item, equivalent to a tax credit of 46%. Therefore, the 15% solar tax credit being currently offered by the Federal Government may not prove to be particularly effective in achieving the goal of reducing consumption of fossil fuels by displacing them with solar systems.

Investments in new tangible property (not including buildings or land), which is used as an integral part of manufacturing, production, extractions, or the furnishing of transportation, communications, electrical energy, gas, water or sewage disposal services, qualifies for investment tax credits. Under current conditions, investment tax credits cannot be taken on buildings, floors, walls, ceilings, and the inside piping, plumbing, and wiring which provide for general services of the building; e.g., office space or cafeteria heating and cooling. Inside plumbing, piping, and wiring, which is provided for process usage, does quality for investment tax credit when these facility improvements are required as an integral part of the activity; for example, wiring required for a lathe or welding machine. The installation of a Solar Power System in an industrial complex to supply electricity and industrial process heat for the facility raises interesting questions regarding application of these investment credit provisions. For example, structural changes required in the building to support an installation of system components would not normally quality for investment tax credit. The piping, plumbing, and wiring required to provide process heat to the industrial facility would normally qualify.

Under a program to stimulate the market, inclusion of all improvements needed for the Solar Power System should be included in the criteria for investment tax credit qualifications. Simi-

larly, land area required for the solar collector arrays could be given special consideration, such as exemption from property taxation.

The solar energy industry would be expected to encourage legislature which grants the investment tax credits and has broad interpretation of tangible and real property comprising the SPS.

From the manufacturers viewpoint, the market potential for SPS must exist first before the firm will be willing to make investments required for mass production. However, assuming that the market exists, most firms have set return-on-investment requirements which must be met before appropriations for plant and equipment will be approved. Appropriate tax law changes, for example, an investment tax credit of 25% vs 10% for the production equipment, would be effective in shifting the time at which the required ROI would be reached. This might have the effect of moving ROI from four years back to three years and would help stimulate investment in mass production capability.

4.2.3 DEPRECIATION SCHEDULES

The rate at which Solar Power Systems are depreciated can have a strong influence on the ultimate saleability of these systems to all types of users. For example, if purchased by an industrial or commercial firm, the fastest possible depreciation rate negotiable with the Internal Service would enhance the SPS economic competitiveness with conventional energy sources. The shorter the depreciation schedule, the more the investment appears as an expense item with the resultant beneficial effect on yearly cash flow. On the other hand, an electric utility firm purchasing the SPS might possibly want the longest depreciation schedule so that the investment could be included in its capital account, which forms the basis for applying the rate of return permitted by the Public Utility Commission.

Regulations permitting the purchaser of the SPS to have the option of selecting the depreciation schedule which most favorably influences his overall business operations would be a market stimulant.

Accelerated depreciation of SPS production equipment by system manufacturers would help to encourage firms to make the required investments. Also, it would reduce the risk associated with obsolete manufacturing equipment which could be encountered with rapidly-evolving technology. Manufacturers will be reluctant to invest in new equipment which may become obsolete before the market really begins to develop and grow.

4.2.4 SUBSIDIES AND LOW INTEREST LOANS

Low interest loans, rather than loan guarantees are expected to be favorably received by all categories of potential SPS users. Even when competitive on a life-cycle basis, the high initial cost for the SPS will represent a major barrier to its purchase by many business firms who must go into the open market to obtain capital. Government policies to help reduce the cost of capital would be an effective incentive in the commercialization of these systems. A subsidy from the Federal Government could be achieved by the Government paying the differential between the capital market interest rate and the incentive loan rate. Through these subsidies, tax dollars would be used to help pay the interest costs only and would not be used to provide the necessary capital. Another alternative would be for the Government to make low interest loans directly to firms or institutions desiring to purchase and install SPS. Such loans would require larger outlays of Federal funds, but would offer a major incentive to potential purchasers who might not otherwise be able to obtain required capital from the open market.

Purchasers of SPS as well as manufacturers of these systems could be benefited by direct Government grants or subsidies. Such

Federal funds could cover a percentage of the total cost of the system. Similarly, direct Federal grants or subsidies would reduce the cost of entering the business if one is a manufacturer, or the high first cost for the purchaser, which represents a major barrier. While there are precedents for such subsidies, they are usually in connection with purely Government undertakings (defense, space programs, etc.) and are not probable for private sector enterprises.

One of the barriers to installation of SPS would be use taxes, sales taxes, or property tax assessments by state and local Governments. This barrier could be alleviated either through Federal reimbursement of these taxes or by a change in state and local taxation policies for SPS installations. The ultimate commercialization of solar energy equipment will be strongly impacted by state and local tax policies, including waivers and exemptions, as they are applied to solar installations. Low-interest loans have a peripheral benefit with REC's and municipal systems in that the cost-savings they help generate can be passed on to consumers who are responsible for electing or appointing management personnel of these systems. Another incentive that would appear attractive, particularly to utilities, would be one in which the utility would have no principal or interest payments due until the system had been installed and is providing power to the grid. In this manner, the SPS purchaser would be spared a major expense incurred during the construction and installation phase of the system. Payment of construction financing interest through grants or subsidies, or forgiveness of interest on Government loans during this period is viewed as an effective aid to commercialization. Loans guaranteed by the Federal Government have historically been used to acquire low-interest loans. The Rural Electric Cooperatives have benefited from this program since the inception of the Rural Electrification Administration. As the REC systems have grown and expanded, reliance on federal funds has significantly diminished. Non-governmental sources supplied 88% of the loan funds in 1979. However, for a new system

offering like SPS, conventional sources of capital are likely to be difficult to acquire. Therefore, Government-guaranteed loans and low-interest Government loans are key elements of achieving SPS commercialization.

4.2.5 WARRANTIES

SPS purchasers are entitled to the protection offered by the manufacturer of such equipment in the form of warranties or guarantees. This is a very complex subject, with vast ramifications to both the SPS producer and consumer.

Under normal business practices, a percentage of the selling price of a product is allocated to cover the cost of warranty claims. Products are generally warranted to be free from defects in materials and workmanship for certain specified periods of time, and the purchaser is entitled to an equitable adjustment if such defects occur. Warranties for design, fitness for purpose, resale or merchantability are often specifically excluded from a manufacturer's warranty. In addition, warranties are limited to exclude special and consequential damages which may occur as a result of an equipment malfunction. These exclusions are meant to protect a manufacturer from financial exposure of the type which could be envisioned as resulting from the failure of the SPS to produce electricity for the grid or process heat required to maintain the operation of a production line. Liability for the loss of revenue from the interrupted service could be a major risk to the SPS manufacturer if his system had contributed to the interruption of such productions.

Consideration of warranty alternatives is being given in many studies sponsored by Congress and DOE in relation to solar heating and cooling. These studies also address related areas, such as standards, certification, etc. Their prime aim is to

find ways to reduce consumer risk at a time when long-term operating experience is unavailable. The role of Government in these areas is controversial, and it is too early to determine the outcome.

One example of a program under consideration is Government insurance aimed at eliminating the financial risk exposure of an owner or manufacturer of solar energy equipment. This insurance program would, in effect, extend the warranty coverage available to the industrial or commercial user by insuring him for special and consequential damages which are beyond the coverage of the manufacturer's warranty, and could insure him against the loss of revenue for interruption in the operation of his business due to system failure. There is much opposition to this approach because it is claimed that it would subsidize the producer of defective equipment and penalize the producer of more reliable equipment. The progress of Government policy in the warranty area must be watched closely as SPS approaches commercialization.

4.2.6 INTERNATIONAL POLICIES

Most solar energy market projections indicate the international market will develop more rapidly and be larger than the domestic market. Government policies can help stimulate export of solar products, including the SPS. These markets have attractions and should be pursued. However, to achieve commercialization requires that a domestic SPS manufacturing infrastructure be developed and supported. To this end, it is suggested that it would be counterproductive to export anything other than SPS hardware; i.e., a restriction on transfer of high technology manufacturing know how would help avoid developing foreign competition for the U.S. SPS industry. However, low technology, or easily produced SPS components; e.g., foundations, counterweights, etc. could be manufactured in the foreign environment while retaining high technology aspects to protect U.S. producers.

4.3 INDUSTRIAL INVOLVEMENT

This section describes some of the industrial factors affecting SPS long-range commercialization. Firms entering the business of manufacturing or assembling SPS systems and components will continue to base their decisions on traditional investment criteria, which varies broadly across U.S. industry. This section highlights some of the non-financial considerations involved in the commercialization process.

4.3.1 PRODUCT INTRODUCTION

Because of the size and complexity of SPS and the present or future commercial availability of some of the major components (e.g., solar collectors, Stirling or Brayton Engines, steam turbines, generators, switchgear, energy storage devices, pumps, controls), it is unlikely that any single manufacturer would fabricate all of the system components. SPS may be offered to the market through a variety of arrangements:

1. A solar products manufacturer who makes some major components, purchases the balance, and assembles a complete system.

2. An engineering firm or packaging firm which does no manufacturing but which purchases all components and constructs a complete system for a client.

Firms producing packaged power plants and conventional fossil fuel systems can be used as models for the future role envisioned for SPS producers. Such firms would have responsibility for engineering systems which provide the best overall balance of thermal and electrical power needed to meet the needs of particular installations, but constrained by the available land area for the solar collector field. They would provide all the required components, whether manufactured by the firm or purchased

from other suppliers, and would offer a total package to the procuring organization. Modular package power systems to satisfy a variety of applications are envisioned as necessary to SPS commercialization. An in-place service, repair and maintenance organization will be required to offer factory authorized services to users. The ability to provide timely and efficient field service is essential to commercialization. Distribution channels must be established, if they do not currently exist, for providing sales and service to consumers. Initial test market and commercial sales of Solar Power Systems will be achieved primarily through direct marketing efforts by the manufacturer. However, full commercialization will only occur when distribution channels are sufficiently mature to assume the lead marketing role for these components and/or systems.

Large industrial manufacturers with extensive financial resources and manufacturing capability will be required to commercialize these systems. The SPS manufacturer must invest in a continued research and development program to achieve engineering advances required for product improvements and cost reductions which are essential for commercialization. Historical precedents established during the introduction and commercialization of steam turbines, gas turbines and nuclear power plants provide insight into the size of the future investment (tens of millions of dollars) requirements for SPS.

A review of these prior programs revealed common elements of commercialization which may be expected to recur in the commercialization of SPS. These are included in Table 4-2.

In all three programs cited above, significant research and development programs resulted in product improvements and increased system competiveness. Also, many years have been required to achieve commercial status for these products, and each has experienced periods of optimistic growth and of significant decline.

TABLE 4-2

COMMON COMMERCIALIZATION ELEMENTS

- Early product introductions were not competitive
- Continuing research and development improved product performance
- Many technological paths were unsuccessful
- Demonstrations and early product proof tests improved reliability and confidence
- Early market stimulation achieved by offering incentives to buyers
- Later market growth and impediments were affected by unpredictable events
- Huge investments were required

Huge investments have been required for facilities and production equipment as well as the continuing R&D programs. The market for these systems has been large enough to be served by several large firms, and competition has resulted in superior end products and improved performance. SPS commercialization will be accelerated by government involvement but will require major industrial investments and at least a decade to achieve when past experiences with these other programs are used to project the future of the SPS.

Actions by industrial firms interested in participating in this market will include independent research and development programs aimed at advancing the state-of-the-art of system components; enlisting support of other commercial product firms or departments who are viewed as potential suppliers to this new market; making corporate investments in plant and equipment necessary to meet the production needs of these systems; establishing market and distribution infrastructure, participation in workshops, seminars and trade associations promoting solar energy; and the publication of non-proprietary data for the benefit of the general public and other firms interested in promoting the SPS.

Tax relief on corporate profits earned on initial production of solar systems would encourage SPS production. This would be particularly attractive if the tax relief is of the form that does not shift the tax burden to other taxpayers. Tax forgiveness or the delay in taxing profits earned by SPS manufacturers might be a way to achieve this effect. Factors listed in Table 4-3 influence business decisions related to commercializing systems such as the SPS. Historically, most technologies have been introduced to the marketplace by the producer of the technology, rather than by some external force or by the demand for the technology. This is especially true for products developed primarily for commercial sale, such as gas and steam turbines, automobiles, office copiers, and major appliances. This is in contrast to high technology military or space products whose market has been established by the customer in advance. Products which have been successfully commercialized on a large scale usually have a history in which both the initiative and the investments required have come from commercial enterprises.

After initial development, the commercial market for SPS can be accelerated through a Government procurement program in which Government-owned facilities would be equipped with SPS; for example, military bases, VA installations, and national laboratories are attractive applications. Purchase of these systems by the Federal Government could encourage the development of an industry to manufacture these systems. In addition, consumer acceptance and recognition of the value of these systems could be enhanced by a high visibility Government procurement programs. One objective would be to provide a pilot market for a sufficiently long period of time for manufacturers to realize some of the economies of scale in production and installation of SPS. Typically, utility firms are conservative and do not purchase new designs of power generation equipment until several years of successful operation have been achieved by test programs. The federal procurement program could provide the system experience demanded by potential utility purchasers.

TABLE 4-3

SIGNIFICANT FACTORS IN INVESTMENT DECISION FOR ENTERING PRODUCTION AND SALES BUSINESS

ENVIRONMENTAL FACTORS

- Business environment and projected changes, i.e. availability of investment capital for system purchasers, competing energy systems and supplies
- Government policies and programs to encourage industry development and anticipated actions to accelerate SPS commercialization and market acceptance
- Environmental acceptability, product safety, risk exposure

MARKETING FACTORS

- Potential market size, characteristics (types of projects, sizes, geographic dispersion, key influences
- Potential competition and characteristics of competitive environment
- Distribution channels, marketing organizations, installation and service resources

TECHNICAL FACTORS

- Demonstrated technical feasibility
- System requirements for sales attractiveness, performance, complexity, maintenance, and economics
- Opportunity for technological breakthroughs, product improvements, and significant cost reductions.

FINANCIAL FACTORS

- SPS ability to reach economic parity with conventional energy systems (may require government incentives for extended periods)
- Significant corporate contributed value in systems and/or components
- Size of investment requirements versus timing of potential recovery and profitability

BUSINESS FACTORS

- SPS synergism with corporate products and services, and relationship of potential market with corporate mission, goals, policies and practices
- Long term business opportunity to develop new product lines
- Industry size sufficient to attract multiple suppliers
- Demonstrable needs for systems by potential customers

4.3.2 ELECTRIC UTILITIES & INDUSTRIAL COGENERATION OPPORTUNITIES

The SPS market demand model projected non-investor-owned utilities as the major near-term market for SPS, whereas industrial applications will be later and limited primarily to cogeneration applications. Conventional cogeneration equipment is only economically justifiable for plants running for the majority of time during the year; i.e., 7000 hours or more. Since the SPS can operate on solar energy about twenty-five percent of the time, fossil firing capability or full capacity parallel backup power must be available. Thus, the SPS output is degraded into being only a "fuel saver." Even in those cases in which waste products are burned to power in-plant generation systems, fossil fuels are also burned. If the SPS is used in these applications, it will help displace fossil fuel and will have value.

The SPS as dispersed power generation plants for isolated loads offers advantages which may help sell these systems; e.g., costs for rights-of-way, distribution systems and transmission losses could be greatly reduced; systems could be installed in less populated areas with minimum environmental impact problems; conventional fuel could be displaced for that portion of the total load provided by solar energy. Historically, utility firms have tended toward larger and larger centralized power stations, and have discouraged smaller dispersed generating stations. There are many good reasons why utilities have developed this philosophy, but future energy scenarios and technological developments such as the SPS could help change some of the underlying reasons which supported large central power station policies.

The sale of both electric power and industrial process steam as a by-product of the electric generation may represent a different business approach for many utility firms. In these installations, the utility would be expected to build, own and operate the SPS and to sell steam to customers at a price no higher than it would have cost the customers to generate their own

process heat. The steam provided would supply base-load steam requirements, and auxiliary non-utility-owned boilers would be used for steam peaking and backup. All electricity produced could be delivered to the user, or as an option, delivered to the utility grid while the customer continued to draw electrical power from the grid at applicable tariff rates. Land for the solar collector field and other SPS components could be either owned by the utility firm, or provided to them on an equitable basis by the energy user.

The intertie between the utility grid and the SPS creates operational constraints on the system and has a strong influence on system design. For example, because of the necessity of the utility to manage its loads, central control stations must be able to exercise some degree of operational control over the system.

Utility firms must be viewed as the most promising potential customer for the SPS, and appropriate actions taken to enlist their active participation and support of this program. In addition to being potential prime customers, utility firms may also be involved in co-ventures with industry or commercial organizations, such as joint ventures, partnerships, subsidiary corporations, lease-purchase arrangements, or similar avenues in which the investments and risks could be shared, and appropriate benefits acquired by all participants.

The outlook for Solar Power Systems is encouraging, particularly when these new systems are considered as part of the cogeneration industry which is receiving a resurgence of interest today. The reinstitution of cogeneration on a broad industrial/commercial basis to achieve the benefits from these systems would enlarge the potential market for solar systems. However, problems facing the future of both conventionally fueled cogeneration and solar systems are similar, in that principle restraints to both are legal and financial barriers as opposed to technological challenges.

Relaxation of Government regulations affecting cogeneration opportunities are underway. With new regulations issued by the Federal Energy Regulatory Commission, the ability to sell excess power to the electric utility is greatly enhanced and thus cogeneration becomes more attractive than previously.

Generally, when industrial firms generate power, it is as a by-product of meeting a thermal need, or the firm has available its own hydro sources. Joint SPS production of thermal-electric output gives much more value to the system output.

An electric utility can almost always generate and sell power more cheaply than the industrial firm can generate its own power (electricity only). Except for cases in which anomolies exist in the utility rate structure; e.g., extensive peak load pricing with very high ratios of peak to offpeak rates for industrial uses, there is an insignificant market in the industrial sector for the electric-only SPS configuration.

Preliminary conclusions for SPS commercialization potential include:

- SPS is technically feasible at this time. Major obstacles to commercialization are non-technical; e.g., high initial system cost; sun rights, tax and other incentives for both manufacturers and consumers; availability and cost of capital; solar equipment standards and certifications; price of competing energy sources; use of simple payback periods or return on investment criteria by consumers vs. life cycle costing.

- Based on past experiences with introduction of new high technology systems, industrial investments of tens of millions of dollars will be needed to bring SPS to the commercial market.

- The government's role in supporting the development and demonstration programs is essential to accelerating system design maturity and achieving commercial acceptance.

- Renewed interest in conventional fuel cogeneration applications and the slowing or reversal of the down-trend in on-site generation will enhance the outlook for SPS.

- Evolving roles and relationships of the program's non-government participants; e.g., system users, utility firms, manufacturers, architects, contractors, and labor unions will directly affect marketing and distribution channels, system ownership, and system applications.

- Commercial market success with these high technology systems may require one or more decades to achieve.

- The Rural Electric Cooperatives and Municipally-Owned Systems offer the best potential for near-term commercialization. Major effort should be concentrated on this market segment.

APPENDIX A

INDUSTRIAL IN-PLANT ELECTRICAL GENERATION

INDUSTRIAL IN-PLANT GENERATION

Approximately 12% to 15% of industrial electricity consumption is self-generated from in-plant generation (IPG) facilities. About 90% of this generation takes place in four SIC groups, as shown in Table 1.

TABLE 1

MAJOR INDUSTRIAL GENERATORS - SOURCE: 1972 CENSUS OF MANUFACTURES

SIC	INDUSTRY	IN-PLANT GENERATION 10^6 KWH
26	Paper	25,457.2
33	Primary Metals	29,643.3
28	Chemicals	19,563.4
29	Petroleum Refining	5,580.7
	TOTAL	75,244.6
	ALL INDUSTRIES	82,828.0

The above data are disaggregated to three and four digit SIC codes in Table 2. Also shown is the percent of total electricity supplied by IPG. Papermills are typically in the 40% to 60% range, while some sugar producers generate over 90% of their requirements. Although primary aluminum and basic steel generate only 20% of their electrical requirements, the large magnitude of their energy needs puts them among the IPG leaders.

TABLE 2
INDUSTRIAL IN-PLANT
GENERATION OF ELECTRICITY

SIC	INDUSTRY	10^6 KWH	PERCENT OF TOTAL KWH
2621	Papermills	12,515.9	42%
3334	Primary Aluminum	10,976.3	20%
2631	Paperboard Mills	10,384.6	61%
2911	Petroleum Refining	5,565.1	20%
2611	Pulpmills	2,314.8	48%
2046	Wet Corn Milling	793.4	53%
3241	Hydraulic Cement	607.1	7%
2421	Sawmills and Planning Mills	586.3	10%
2061	Raw Cane Sugar	446.0	82%
2063	Beet Sugar	402.3	68%
2062	Cane Sugar Refining	397.5	82%
2082	Malt Liquors	209.1	12%
2011	Meat Packing Plants	185.8	5%
2211	Weaving Mills, Cotton	162.3	3%
2833	Medicinals and Botanicals	144.7	26%
3351	Copper Rolling and Drawing	120.1	6%
2221	Weaving Mills, Synthetics	117.6	2%
2111	Cigarettes	101.5	16%
		46,030.4	(about 56% of total industrial IPG)

SIC	INDUSTRY GROUP	10^6 KWH	PERCENT OF TOTAL KWH
281	Industrial Chemicals	15,838.9	17%
331	Blast Furnace, Basic Steel	12,291.6	20%
282	Plastics	3,243.0	19%
30	Rubber and Plastics n.e.c.	629.6	4%
35	Machinery, Except Elec.	371.1	2%
36	Electrical Equipment	147.4	1%
289	Misc. Chemicals	122.3	5%
34	Fabricated Metal Prods.	113.5	1%

$$\text{Percent} = \frac{\text{IPG Electricity}}{\text{Total Electricity Used}}$$

Source - 1972 Census of Manufactures

Although the previous data was taken from the 1972 Census of Manufactures, the data of the 1976 Survey of Manufactures shows the same industries leading in IPG. The 1976 data is far less complete, however.

The best compilation of industrial in-plant generation facilities appears in the annual F.E.R.C. Forms 4 and 12-C, which must be filed by industrial generators. Total generation capacity reported in 1978 was 18,343 megawatts, with annual energy output exceeding 77×10^9 kilowatt hours. About 87% of industrial generation capacity comes from steam turbines, used primarily in a cogenerating mode -- supplying exhaust steam for process heat use. The large generators of Table 2 are, for the most part, large steam users. Steam turbines are typically sized to meet the steam requirements, with electricity as a byproduct.

The remaining 13% industrial capacity falls in three main categories -- hydroelectric, "captive" fuel and standby units. The first is self-explanatory and highly dependent on plant location. "Captive" fuels generation is typified by the oil refinery burning oil in a gas turbine or diesel to generate electricity, or the natural gas pipeline providing its pumping power by burning fuel. Standby units are employed when reliability of power supply is critical.

A complete tabulation of the 1978 Forms 4 and 12-C industrial generation data follows.

ORIGINAL PAGE IS
OF POOR QUALITY

MAINE

COMPANY NUMBER	PLANT TYPE	CAPACITY -KILOWATTS	GENERATION MEGAWATT-HOURS	CAPACITY FACTOR
232	STEAM	23,500	52,822	.257
247	STEAM	67,350	285,108	.483
263	HYDRO	87,000	543,629	.713
263	STEAM	174,124	475,083	.311
316	STEAM	50,000	626,720	1.43
469	STEAM	27,500	114,509	.475
484	STEAM	17,125	73,120	.487
543	STEAM	19,250	159,676	.947
553	STEAM	12,680	39,534	.356
686	STEAM	21,700	73,232	.385
OTHER	HYDRO	78,304	409,056	.596
OTHER	STEAM	26,625	63,024	.270
OTHER	INT. COMB.	982	12	.001
TOTAL	-	606,140	2,915,525	.549

NEW HAMPSHIRE

087	HYDRO	32,540	160,393	.563
087	STEAM	17,000	105,136	.706
OTHER	HYDRO	5,721	10,392	.207
OTHER	STEAM	9,400	19,860	.241
OTHER	INT. COMB.	3,300	0	0
TOTAL	-	67,961	295,781	.497

VERMONT

OTHER	HYDRO	12,095	74,364	.702
OTHER	STEAM	2,590	10,824	.477
OTHER	INT. COMB.	1,190	252	.024
TOTAL	-	15,875	85,440	.614

MASSACHUSETTS

076	HYDRO	8,665	18,635	.246
243	STEAM	65,625	154,100	.268
263	STEAM	17,000	63,095	.424
324	STEAM	13,500	43,769	.370
390	STEAM	60,000	0	0
390	STEAM	120,000	108,733	.103
OTHER	HYDRO	14,482	43,620	.344
OTHER	STEAM	93,576	325,896	.398
OTHER	INT. COMB.	800	288	.041
TOTAL	-	393,648	758,136	.220

ORIGINAL PAGE IS
OF POOR QUALITY

RHODE ISLAND

COMPANY NUMBER	PLANT TYPE	CAPACITY -KILOWATTS	GENERATION MEGAWATT-HOURS	CAPACITY FACTOR
OTHER	STEAM	5,675	20,436	.411
TOTAL	-	5,675	20,436	.411

CONNECTICUT

118	STEAM	11,000	0	0
243	STEAM	15,000	21,169	.161
482	STEAM	21,500	45,944	.244
488	STEAM	11,000	48,124	.499
553	STEAM	17,250	21,544	.143
OTHER	HYDRO	1,360	6,552	.550
OTHER	STEAM	17,475	71,424	.467
OTHER	INT. COMB.	2,074	0	0
TOTAL	-	96,659	214,757	.254

NEW YORK

013	STEAM	54,500	293,532	.615
029	STEAM	10,400	30,669	.337
066	STEAM	47,500	82,243	.198
141	STEAM	23,500	0	0
193	STEAM	113,700	1,003,014	1.01
243	STEAM	27,500	133,728	.555
317	HYDRO	11,800	64,016	.619
317	STEAM	27,500	134,688	.559
317	STEAM	30,000	203,420	.774
505	STEAM	10,500	43,649	.475
521	STEAM	10,000	36,183	.413
OTHER	HYDRO	30,710	176,844	.657
OTHER	STEAM	76,409	213,084	.327
OTHER	INT. COMB.	1,240	0	0
TOTAL	-	475,259	2,421,070	.582

NEW JERSEY

019	STEAM	14,500	66,175	.521
239	STEAM	14,500	69,439	.547
242	STEAM	11,700	10,666	.104
327	STEAM	14,500	24,441	.192
417	STEAM	32,700	169,148	.590
436	STEAM	15,000	47,156	.359
612	STEAM	24,000	101,784	.484

ORIGINAL PAGE IS
OF POOR QUALITY

NEW JERSEY (continued

COMPANY NUMBER	PLANT TYPE	CAPACITY -KILOWATTS	GENERATION MEGAWATT-HOURS	CAPACITY FACTOR
703	STEAM	10,000	60,873	.695
OTHER	HYDRO	1,164	3,252	.319
OTHER	STEAM	69,830	244,440	.400
OTHER	INT. COMB.	100	0	0
TOTAL	-	207,994	797,374	.438

PENNSYLVANIA

029	STEAM	10,500	30,183	.328
032	STEAM	16,950	69,913	.471
034	STEAM	35,000	70,722	.231
066	STEAM	26,500	109,433	.471
066	INT. COMB.	17,500	56,273	.367
066	STEAM	74,500	74,395	.114
147	STEAM	11,000	59,708	.620
159	STEAM	24,000	41,712	.198
243	STEAM	20,000	151,470	.865
251	STEAM	21,500	153,407	.815
269	STEAM	36,000	149,952	.475
274	STEAM	40,500	198,253	.559
274	STEAM	14,500	49,849	.392
329	STEAM	47,000	126,640	.308
329	STEAM	70,000	123,636	.202
541	STEAM	100,000	623,846	.712
553	STEAM	10,400	70,326	.772
562	STEAM	10,000	24,681	.282
636	STEAM	60,000	327,853	.624
636	STEAM	35,000	204,405	.667
636	INT. COMB.	43,500	236,903	.622
636	STEAM	65,000	156,760	.275
636	STEAM	62,000	364,055	.670
636	STEAM	10,000	3,409	.039
636	STEAM	10,000	18,517	.211
664	STEAM	22,500	56,311	.286
701	STEAM	17,100	50,499	.337
OTHER	HYDRO	250	0	0
OTHER	STEAM	73,150	125,484	.196
OTHER	INT. COMB.	0	0	-
TOTAL	-	984,350	3,728,275	.432

OHIO

112	STEAM	10,010	18,703	.213
222	STEAM	57,500	61,320	.122
257	STEAM	64,500	159,580	.282
315	STEAM	20,000	-	-
364	STEAM	27,600	5,737	.024
399	STEAM	74,125	372,281	.573

ORIGINAL PAGE IS
OF POOR QUALITY

OHIO (continued)

COMPANY NUMBER	PLANT TYPE	CAPACITY -KILOWATTS	GENERATION MEGAWATT-HOURS	CAPACITY FACTOR
472	STEAM	14,000	85,658	.698
494	STEAM	83,750	367.019	.500
505	STEAM	12,500	64,436	.588
521	STEAM	42,500	170,309	.457
521	STEAM	10,500	62,783	.683
521	STEAM	27,500	75,551	.314
573	STEAM	17,500	63,213	.412
628	STEAM	160,000	850,200	.607
635	STEAM	24,500	100,618	.469
636	STEAM	28,000	14,607	.060
636	STEAM	10,000	310	.004
636	STEAM	45,000	101,138	.257
702	STEAM	11,000	-	-
722	STEAM	48,500	49,129	.116
OTHER	STEAM	95,098	229,872	.276
OTHER	INT. COMB.	3,728	120	.004
TOTAL	-	887,811	2,852,584	.367

INDIANA

010	STEAM	582,000	3,436,345	.674
022	STEAM	14,700	78,250	.608
029	STEAM	63,750	459,611	.823
042	STEAM	24,000	108,055	.514
308	STEAM	55,000	0	0
315	STEAM	212,500	969,757	.521
636	STEAM	60,000	400,241	.761
722	STEAM	99,400	303,966	.349
OTHER	STEAM	16,550	59,448	.410
OTHER	INT. COMB.	2,425	1,680	.079
TOTAL	-	1,130,325	5,817,353	.588

ILLINOIS

014	STEAM	23,150	81,291	.401
029	STEAM	12,000	104,320	.992
151	STEAM	27,000	186,247	.787
151	STEAM	16,500	80,299	.556
170	STEAM	10,000	39,700	.453
260	STEAM	21,000	0	0
260	STEAM	15,000	28,433	.216
364	STEAM	31,900	47,215	.169
386	STEAM	12,000	69,133	.658
421	STEAM	13,500	60,733	.514
562	STEAM	20,000	76,675	.438
585	STEAM	22,000	99,717	.517

ILLINOIS (continued)

ORIGINAL PAGE IS
OF POOR QUALITY

COMPANY NUMBER	PLANT TYPE	CAPACITY -KILOWATTS	GENERATION MEGAWATT-HOURS	CAPACITY FACTOR
635	STEAM	12,500	81,809	.797
636	STEAM	105,000	385,488	.419
699	STEAM	52,500	195,655	.425
OTHER	HYDRO	2,752	18,048	.749
OTHER	STEAM	47,218	99,456	.241
OTHER	INT. COMB.	16,008	34,956	.249
TOTAL	-	460,028	1,689,175	.419

MICHIGAN

087	STEAM	12,500	53,173	.486
087	STEAM	19,850	89,394	.514
130	INT. COMB.	10,000	2,974	.034
183	STEAM	191,000	0	0
183	STEAM	17,500	72,780	.475
227	STEAM	345,000	1,346,081	.445
247	STEAM	20,000	75,324	.430
294	STEAM	12,500	44,858	.410
305	STEAM	42,500	288,633	.775
399	STEAM	58,300	393,807	.771
406	STEAM	10,000	48,981	.559
472	STEAM	17,500	134,267	.876
553	STEAM	11,500	44,162	.438
628	STEAM	10,000	41,729	.476
686	STEAM	18,500	170,428	1.052
704	STEAM	52,000	179,723	.395
704	GAS TURB.	20,000	225	.001
OTHER	HYDRO	32,714	123,156	.430
OTHER	STEAM	84,650	403,296	.544
OTHER	INT. COMB.	1,292	96	.001
TOTAL	-	987,306	3,513,087	.406

WISCONSIN

013	STEAM	13,900	262	.002
145	STEAM	40,125	158,905	.453
145	STEAM	26,500	178,029	.767
145	STEAM	12,500	69,873	.638
212	INT. COMB.	14,960	39,918	.305
393	STEAM	10,300	54,264	.601
425	STEAM	10,000	64,834	.740
441	STEAM	23,500	125,840	.611
448	STEAM	12,000	39,551	.376
543	STEAM	25,000	109,465	.500
549	STEAM	10,000	21,992	.251

ORIGINAL PAGE IS
OF POOR QUALITY

WISCONSIN (continued)

COMPANY NUMBER	PLANT TYPE	CAPACITY -KILOWATTS	GENERATION MEGAWATT-HOURS	CAPACITY FACTOR
615	STEAM	39,100	184,908	.540
OTHER	HYDRO PLTS	52,048	273,924	.601
OTHER	STEAM	92,755	414,960	.511
OTHER	INT. COMB.	1,600	6,312	.450
TOTAL	-	384,288	1,743,037	.518

MINNESOTA

075	STEAM	29,250	149,648	.584
206	STEAM	225,000	921,073	.467
227	HYDRO	14,400	95,413	.756
232	STEAM	11,375	46,900	.471
521	STEAM	125,000	892,168	.815
636	STEAM	15,000	14,414	.110
682	STEAM	25,200	115,744	.524
OTHER	HYDRO	19,824	60,468	.348
OTHER	STEAM	55,871	263,640	.539
OTHER	INT. COMB.	7,001	456	.007
TOTAL	-	527,921	2,559,924	.554

IOWA

131	STEAM	25,000	141,721	.647
170	STEAM	11,100	53,342	.549
170	STEAM	16,500	78,197	.541
360	STEAM	11,500	16,619	.165
OTHER	HYDRO	300	1,044	.397
OTHER	STEAM	14,365	82,728	.657
TOTAL	-	78,765	373,651	.542

MISSOURI

029	STEAM	21,000	124,218	.675
031	STEAM	23,500	63,728	.310
287	STEAM	22,500	97,473	.495
436	STEAM	15,000	12,511	.095
OTHER	STEAM	15,000	69,756	.531
OTHER	INT. COMB.	675	3 096	.524
TOTAL	-	97,675	370,782	.433

ORIGINAL PAGE IS
OF POOR QUALITY

NORTH DAKOTA

COMPANY NUMBER	PLANT TYPE	CAPACITY -KILOWATTS	GENERATION MEGAWATT-HOURS	CAPACITY FACTOR
OTHER	STEAM	15,675	71,520	.521
OTHER	INT. COMB.	2,775	14,544	.598
TOTAL	-	18,450	86,064	.533

SOUTH DAKOTA

OTHER	HYDRO	8,400	33,744	.459
TOTAL	-	8,400	33,744	.459

KANSAS

269	STEAM	20,000	3,955	.023
OTHER	INT. COMB.	6,487	24,516	.431
OTHER	STEAM	15,350	83,580	.614
TOTAL	-	41,837	112,051	.306

DELAWARE

187	STEAM	22,500	207,129	1.051
OTHER	STEAM	6,500	22,992	.404
TOTAL	-	29,000	230,121	.906

MARYLAND

029	STEAM	11,250	40,472	.411
066	STEAM	140,000	759,082	.648
652	STEAM	10,000	36,063	.412
701	STEAM	44,000	216,847	.563
OTHER	STEAM	3,050	29,412	1.101
TOTAL	-	208,300	1,081,876	.593

DISTRICT OF COLUMBIA

645	STEAM	12,500	272	.002
TOTAL	-	12,500	272	.002

ORIGINAL PAGE IS
OF POOR QUALITY

VIRGINIA

COMPANY NUMBER	PLANT TYPE	CAPACITY -KILOWATTS	GENERATION MEGAWATT-HOURS	CAPACITY FACTOR
013	STEAM	24,500	0	0
032	STEAM	32,500	141 470	.498
112	STEAM	25,500	209,941	.940
119	STEAM	56,750	305,553	.615
147	STEAM	15,000	106,684	.812
165	STEAM	19,400	41,725	.246
187	STEAM	15,000	123,498	.940
187	STEAM	31,880	71,339	.255
187	STEAM	12,000	65,519	.623
628	STEAM	81,500	442,669	.620
668	STEAM	19,500	45,335	.265
668	STEAM	24,000	58,063	.276
701	STEAM	65,000	272,796	.479
OTHER	HYDRO	10,705	33,372	.356
OTHER	STEAM	32,060	138,084	.492
TOTAL	-	465,295	2,056,318	.505

WEST VIRGINIA

032	STEAM	17,500	82,267	.537
226	STEAM	35,000	123,446	.403
494	STEAM	118,500	529,427	.510
628	HYDRO	102,000	479,501	.537
628	STEAM	123,000	207,400	.192
628	STEAM	16,000	34,157	.244
628	STEAM	10,000	71,150	.812
693	STEAM	108,250	447,223	.472
OTHER	HYDRO	4,680	31,140	.760
OTHER	STEAM	.5,500	18,192	.378
TOTAL	-	540,430	2,023,903	.428

NORTH CAROLINA

009	STEAM	22,500	153,584	.779
019	STEAM	23,750	64,158	.308
027	STEAM	10,000	0	0
104	STEAM	27,000	63,427	.268
116	STEAM	51,000	291,206	.652
187	STEAM	15,000	37,855	.288
218	STEAM	47,500	292,702	.703
463	STEAM	16,000	118,169	.843
522	STEAM	32,500	93,350	.328
702	STEAM	58,400	591,533	1.156
OTHER	HYDRO	4,825	2,496	.059
OTHER	STEAM	18,125	48,132	.303
TOTAL	-	326,600	1,756,612	.614

SOUTH CAROLINA

COMPANY NUMBER	PLANT TYPE	CAPACITY -KILOWATTS	GENERATION MEGAWATT-HOURS	CAPACITY FACTOR
078	STEAM	42,500	296,210	.796
112	STEAM	28,500	160,600	.643
187	STEAM	10,000	72,428	.827
317	STEAM	52,500	316,116	.687
573	STEAM	26,200	132,129	.576
584	STEAM	22,500	96,448	.489
640	STEAM	110,500	402,391	.416
701	STEAM	48,250	309,308	.732
OTHER	HYDRO	12,656	46,596	.420
OTHER	STEAM	23,500	47,388	.230
TOTAL	-	377,106	1,879,614	.569

GEORGIA

089	STEAM	36,000	229,293	.427
147	STEAM	19,500	131,765	.771
247	STEAM	17,500	145,592	.950
247	STEAM	39,500	300,220	.868
250	STEAM	28,500	205,204	.822
263	STEAM	68,000	508,101	.853
468	STEAM	15,000	96,045	.731
515	STEAM	50,000	160,922	.367
628	STEAM	90,375	642,789	.812
OTHER	HYDRO	13,575	57,372	.483
OTHER	STEAM	33,975	147,816	.497
OTHER	INT. COMB.	2,025	396	.022
TOTAL	-	413,950	2,625,515	.724

FLORIDA

014	STEAM	11,500	79,222	.786
090	STEAM	32,500	262,378	.922
147	STEAM	54,000	508,964	1.076
239	STEAM	11,500	78,176	.776
239	INT. COMB.	225	48	.024
302	STEAM	50,404	367,613	.833
317	STEAM	44,510	278,401	.714
421	STEAM	16,250	98,646	.693
515	STEAM	33,500	105,471	.359
541	STEAM	53,000	238,181	.513
542	STEAM	32,000	231,472	.826
543	STEAM	42,000	241,175	.656
600	STEAM	15,000	30,648	.233
OTHER	STEAM	18,000	37,020	.235
OTHER	INT. COMB.	6,225	23,304	.427
TOTAL	-	420,614	2,580,719	.700

ORIGINAL PAGE IS
OF POOR QUALITY

KENTUCKY

COMPANY NUMBER	PLANT TYPE	CAPACITY -KILOWATTS	GENERATION MEGAWATT-HOURS	CAPACITY FACTOR
OTHER	STEAM	7,320	17,916	.279
TOTAL	-	7,320	17,916	.279

TENNESSEE

019	STEAM	20,000	87,344	.499
058	STEAM	24,000	81,156	.386
078	STEAM	45,000	377,820	.958
193	STEAM	141,500	810,019	.653
399	STEAM	22,000	117,071	.607
OTHER	STEAM	11,600	31,380	.309
TOTAL	-	264,100	1,504,790	.650

ALABAMA

015	STEAM	22,500	73,616	.373
018	STEAM	31,250	277,568	1.014
147	STEAM	25,000	19,886	.091
317	STEAM	98,500	449,238	.521
342	STEAM	37,500	228,433	.695
521	STEAM	20,000	106,527	.608
553	STEAM	44,000	189,114	.491
628	STEAM	25,000	251,330	1.148
635	STEAM	25,000	25,646	.117
636	STEAM	10,000	53,357	.609
636	STEAM	11,000	702	.007
OTHER	HYDRO	8,000	338,124	4.825
OTHER	STEAM	33,750	162,300	.549
OTHER	INT. COMB.	1,500	6,780	.516
TOTAL	-	393,000	2,182,621	.634

MISSISSIPPI

317	STEAM	25,000	201,123	.918
317	STEAM	28,500	182,448	.731
317	STEAM	32,500	245,780	.863
OTHER	STEAM	2,000	6,468	.369
TOTAL	-	88,000	635,819	.825

ORIGINAL PAGE IS
OF POOR QUALITY

ARKANSAS

COMPANY NUMBER	PLANT TYPE	CAPACITY -KILOWATTS	GENERATION MEGAWATT-HOURS	CAPACITY FACTOR
015	STEAM	22,500	213,823	1.085
247	STEAM	44,500	334,599	.858
316	STEAM	12,000	60,365	.574
522	INT. COMB.	78,800	595,753	.863
OTHER	STEAM	16,650	3,888	.027
OTHER	INT. COMB.	9,920	87,192	1.003
TOTAL	-	184,370	1,295,620	.802

LOUISIANA

013	STEAM	20,500	27,086	.151
013	GAS TURBINE	70,588	248,522	.402
075	STEAM	52,500	187,055	.407
098	STEAM	12,450	4,054	.037
125	STEAM	75,000	239,080	.364
141	STEAM	7,500	-	-
147	STEAM	43,650	422,997	1.106
148	STEAM	11,750	24,217	.235
150	STEAM	14,000	26,460	.216
183	GAS TURBINE	32,400	-	-
317	STEAM	56,000	370,064	.754
317	STEAM	71,000	313,429	.504
332	STEAM	24,000	173,141	.824
332	STEAM	398,000	3,695,608	1.060
332	INT. COMB.	103,200	786,697	.870
332	STEAM	38,270	286,230	.854
332	GAS TURBINE	48,000	467,950	1.113
463	STEAM	53,000	425,788	.917
463	STEAM	14,000	58,665	.478
494	STEAM	113,100	419,470	.423
494	GAS. TURBINE	73,100	691,624	1.080
494	STEAM	166,180	898,692	.617
612	STEAM	12,000	62,654	.596
OTHER	STEAM	69,220	248,436	.410
OTHER	INT. COMB.	28,453	79,176	.318
TOTAL	-	1,607,861	10,157,095	.721

OKLAHOMA

148	STEAM	18,000	69,849	.493
OTHER	STEAM	2,050	4,104	.229
OTHER	INT. COMB.	7,794	56,172	.823
TOTAL	-	27,844	130,125	.534

ORIGINAL PAGE IS
OF POOR QUALITY

TEXAS

COMPANY NUMBER	PLANT TYPE	CAPACITY -KILOWATTS	GENERATION MEGAWATT-HOURS	CAPACITY FACTOR
015	STEAM	30,000	262,192	.998
015	INT. COMB.	324,435	316,425	.111
025	STEAM	21,500	-	-
029	STEAM	35,200	278,610	.904
029	GAS TURBINE	39,400	160,660	.465
130	STEAM	10,000	27,987	.319
177	STEAM	42,500	157,763	.429
183	STEAM	290,000	-	-
183	STEAM	192,000	-	-
183	STEAM	207,000	-	-
183	STEAM	180,000	-	-
183	GAS TURBINE	30,000	0	0
187	STEAM	15,000	80,780	.615
190	STEAM	40,200	80,000	.227
211	STEAM	60,000	97,173	.185
211	GAS TURBINE	114,400	852,008	.850
211	INT. COMB.	12,000	75,673	.720
211	STEAM	15,000	61,914	.471
269	STEAM	63,000	308,677	.559
269	GAS TURBINE	44,050	215,189	.558
313	STEAM	330,750	2,283,711	.788
317	STEAM	65,000	311,500	.547
371	STEAM	32,875	267,059	.927
417	STEAM	135,000	699,090	.591
487	STEAM	70,000	209,104	.341
494	STEAM	37,500	53,829	.164
522	INT. COMB.	235,060	0	0
522	STEAM	24,000	179,769	.855
522	GAS TURBINE	15,000	77,500	.590
544	INT. COMB.	23,410	58,220	.284
561	STEAM	35,000	167,234	.545
562	GAS TURBINE	25,000	175,400	.801
579	STEAM	55,000	323,044	.670
579	GAS TURBINE	25,000	132,629	.606
579	STEAM	78,500	413,974	.602
612	STEAM	131,125	691,771	.602
628	STEAM	121,165	386,478	.364
628	GAS TURBINE	26,800	0	0
OTHER	HYDRO	738	5,256	.813
OTHER	STEAM	90,650	353,904	.446
OTHER	INT. COMB.	140,286	633,252	.515
TOTAL	-	3,463,544	10,397,774	.343

MONTANA

OTHER	STEAM	4,000	10,620	.303
TOTAL	-	4,000	10,620	.303

ORIGINAL PAGE IS
OF POOR QUALITY

IDAHO

COMPANY NUMBER	PLANT TYPE	CAPACITY -KILOWATTS	GENERATION MEGAWATT-HOURS	CAPACITY FACTOR
015	STEAM	10,925	3,251	.034
501	STEAM	10,000	101,796	1.162
OTHER	STEAM	20,250	30,300	.171
TOTAL	-	41,175	135,347	.375

WYOMING

226	STEAM	42,000	164,460	.447
591	STEAM	17,500	103,204	.673
OTHER	STEAM	13,186	37,368	.324
OTHER	INT. COMB.	3,025	8,868	.335
TOTAL	-	75,711	313,900	.473

COLORADO

137	STEAM	48,750	72,091	.169
OTHER	STEAM	15,500	96,972	.714
OTHER	INT. COMB.	5,100	22,320	.500
TOTAL	-	69,350	191,383	.315

NEW MEXICO

336	STEAM	74,000	141,046	.218
419	INT. COMB.	21,500	29,857	.159
OTHER	STEAM	17,300	113,940	.752
OTHER	INT. COMB.	33,987	121,848	.409
TOTAL	-	146,787	406,691	.316

ARIZONA

029	INT. COMB.	57,700	91,115	.180
189	INT. COMB.	14,000	0	0
315	STEAM	25,500	0	0
336	STEAM	10,000	36,991	.422
381	STEAM	32,975	151,961	.526
488	INT. COMB.	11,200	36,774	.375
488	STEAM	16,000	63,620	.454
488	STEAM	108,000	0	0

ORIGINAL PAGE IS
OF POOR QUALITY

ARIZONA (CONTINUED)

COMPANY NUMBER	PLANT TYPE	CAPACITY -KILOWATTS	GENERATION MEGAWATT-HOURS	CAPACITY FACTOR
OTHER	HYDRO	2,400	16,140	.768
OTHER	STEAM	16,750	75,480	.514
OTHER	INT. COMB.	4,600	3,468	.086
TOTAL	-	299,125	475,549	.182

UTAH

336	STEAM	175,000	873,819	.570
336	STEAM	15,000	27,230	.207
636	STEAM	50,000	516,404	1.179
OTHER	STEAM	4,234	0	0
TOTAL	-	244,234	1,417,453	.663

NEVADA

336	STEAM	45,000	8,081	.021
591	STEAM	24,000	108,031	.514
TOTAL	-	69,000	116,112	

WASHINGTON

159	STEAM	12,000	36,378	.346
159	HYDRO	10,800	55,913	.591
159	HYDRO	14,850	91,122	.700
159	STEAM	15,850	15,713	.113
372	STEAM	71,080	30,375	.049
515	STEAM	10,250	5,480	.058
515	STEAM	14,500	10,003	.079
566	STEAM	11,000	7,668	.080
702	STEAM	20,000	-	-
702	STEAM	72,750	135,635	.213
702	STEAM	18,000	13,640	.087
702	STEAM	15,000	27,390	.208
OTHER	STEAM	66,900	141,732	.242
OTHER	INT. COMB.	5,650	42,828	.865
TOTAL	-	359,130	613,877	.195

ORIGINAL PAGE IS
OF POOR QUALITY

OREGON

COMPANY NUMBER	PLANT TYPE	CAPACITY -KILOWATTS	GENERATION MEGAWATT-HOURS	CAPACITY FACTOR
159	HYDRO	13,900	7,171	.059
533	STEAM	37,500	230,063	.700
702	STEAM	25,000	856	.004
OTHER	HYDRO	2,250	7,548	.383
OTHER	STEAM	81,916	181,752	.253
OTHER	INT. COMB.	150	120	.091
TOTAL	-	160,716	427,510	.304

CALIFORNIA

099	STEAM	13,000	71,586	.629
159	STEAM	23,000	146,882	.729
159	STEAM	12,500	74,597	.681
247	STEAM	14,000	68,720	.560
339	STEAM	100,125	198,430	.226
374	STEAM	27,500	192,686	.800
470	STEAM	20,000	37,015	.211
527	STEAM	15,000	71,720	.546
587	STEAM	19,575	107,583	.627
591	GAS TURBINE	15,500	98,430	.725
OTHER	HYDRO	1,600	0	0
OTHER	STEAM	62,425	295,200	.540
OTHER	INT. COMB.	7,200	27,624	.438
TOTAL	-	331,425	1,390,473	.479

ALASKA

009	STEAM	24,375	172,104	.806
339	STEAM	38,600	103,979	.308
OTHER	INT. COMB.	7,360	12,960	.201
TOTAL	-	70,335	289,043	.469

HAWAII

282	STEAM	24,000	64,715	.308
292	STEAM	23,800	114,096	.547
394	STEAM	15,500	23,154	.171
457	STEAM	16,500	74,329	.514
492	STEAM	12,250	43,140	.402
507	STEAM	15,000	58,192	.443
OTHER	HYDRO	15,007	14,802	.113
OTHER	STEAM	39,500	115,116	.333
OTHER	INT. COMB.	3,980	10,140	.291
TOTAL	-	165,537	517,684	.357

APPENDIX B

MATERIAL USED FOR PERSONAL INTERVIEWS AND MAIL SURVEY

B-1. QUESTIONNAIRES FOR USE IN CONDUCTING PERSONAL INTERVIEWS AND MAIL SURVEYS WITH ELECTRICAL UTILITY FIRMS

GENERAL ELECTRIC

ORIGINAL PAGE IS
OF POOR QUALITY

THESE FORMS WERE USED FOR PERSONAL INTERVIEWS

SOLAR POWER SYSTEMS UTILITY MARKET STUDY

As we explained previously, I am here representing General Electric's Space Division and would like to discuss with you a product concept which you will probably find useful in your long range planning for energy needs.

First, I'd like to discuss briefly with you, your current and anticipated system generation characteristics.

1. a) Currently for this system, what are your approximate annual electricity sales? b) And what is peak demand? (RECORD BELOW)

2. a) And in about 10 years, what do you anticipate your annual sales to be?
 b) And the peak demand? (RECORD BELOW)

POWER REQUIREMENTS

	1) Current	2) 10 Years
a. Electricity sales	_____ MWh	_____ MWh
b. Peak Demand	_____ MW	_____ MW

3. a) And approximately what percentage of your requirements are currently purchased? b) And what would that percentage be in 10 Years?

IF "ALL" SKIP TO Q.6

a. Current _____%

b. 10 Years _____%

4. a) (ASK GENERATORS ONLY) Please tell me about what percentage of each equipment type is currently used in your generating mix? (READ LIST)

EQUIPMENT TYPE	% OF MIX
Nuclear	_____
Hydro	_____
Coal	_____
Oil	_____
Gas	_____
Other (SPECIFY)	_____
_____	_____
_____	_____
_____	_____
_____	_____

5. (ASK GENERATORS ONLY) Now, in reference to the fuels you are currently using, what do you feel the outlook is for the 1990 time period, in terms of both availability and price?

 a) What about (FIRST FUEL TYPE)? Do you feel that the availability of (FUEL) will be unlimited, partially limited or severely limited? (RECORD BELOW)
 b) And about what percentage price change do you anticipate between now and 1990 for (FUEL)?

(REPEAT A&B FOR EACH FUEL TYPE CURRENTLY USED. RECORD BELOW)

FUEL TYPE (SPECIFY)	AVAILABILITY - 1990			PRICE CHANGE CURRENT TO 1990 (%)	
	UNLIMITED	PARTIALLY LIMITED	SEVERELY LIMITED	+	-
_____	____	____	____	____	____
_____	____	____	____	____	____
_____	____	____	____	____	____
_____	____	____	____	____	____
_____	____	____	____	____	____

6. (ASK ONLY IF NOT 100% SELF GENERATED)
 a) And about the electric power you are currently purchasing, again in about 1990 do you feel this source is unlimited and/or reliable, or do you see some possible problem? (IF PROBLEM, DEFINE)

UNLIMITED/RELIABLE _____

PROBLEM _____

PROBLEM AREAS:

 b) And about what percentage change do you anticipate in the cost of purchased electrical power between now and 1990?

\+ _____%

\- _____%

ORIGINAL PAGE IS
OF POOR QUALITY

7. Several alternatives for dealing with future energy requirements have been mentioned as possibilities by utilities such as yours. Please describe the likelihood of each of these being adopted by your system between now and 1990. Use a scale running from "0" meaning "Not at All Likely" to "10" meaning "Extremely Likely." You may base this rating on either specific plans made by your system or your experience and judgment. (READ LIST)

ACTION	LIKELIHOOD
I. Increase generating capabilities by:	
a. addition of nuclear plants	_____
b. addition of coal fired plants	_____
c. addition of other fossil fired plants	_____
d. Other (SPECIFY)	
_____	_____
_____	_____
II. Conversion to other fuel types: (SPECIFY TYPES)	
FROM TO	
_____ _____	_____
_____ _____	_____
_____ _____	_____
III. Purchase share in large units	_____
IV. Add energy storage:	
a. Pumped hydro	_____
b. Other	_____

V. Purchase some or greater percentage of requirements	_____
VI. Other (SPECIFY)	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

ORIGINAL PAGE IS
OF POOR QUALITY

THIS PAGE WAS USED FOR REGION 1

8 . Now, I would like to discuss with you the solar energy concept you have already reviewed. As stated, in your particular solar area, the system requires 13 to 15 acres per megawatt, has a projected capital cost of $1300/KW, with a busbar energy cost of 6 to 7.5¢/kWh for electricity only; however, if process heat credit is included, this cost drops to 4 to 5.5¢/kWh. Costs are stated in 1979 dollars, and exclude land costs. Estimates are based on forty percent capacity factor from Solar input only.

a) I have here some items that may or may not affect consideration of a solar plant such as this by a system like yours. As I read each item, please tell me how influential you feel it would be when considering a solar energy system by rating that item on a scale from "0" meaning "Not At All Influential" to "10" meaning "Extremely Influential."

b) And for some of those items that I will mention, please tell me how well this particular solar system might meet your system's needs or requirements. This time "0" will mean "Very Poor" and "10" will mean "Extremely Well." (DO NOT ASK 10b FOR * STATEMENTS)

	8a INFLUENCE IN CONSIDERATION	8b HOW WELL MEETS NEEDS
1. Protection against fuel price escalation	_____	_____
2. Initial price of $1,300 per kilowatt	_____	_____
3. Appearance - aesthetics of the system	_____	_____
*4. Demonstrations of system operation in your solar regions	_____	[redacted]
5. Land requirements of 13 to 15 acres per megawatt	_____	_____
6. Your own company's energy policy	_____	_____
7. Pollution credits and/ or meeting local standards	_____	_____

ORIGINAL PAGE IS
OF POOR QUALITY

THIS PAGE WAS USED FOR REGION 1

ORIGINAL PAGE IS
OF POOR QUALITY

		8a INFLUENCE IN CONSIDERATION	8b HOW WELL MEETS NEEDS
8.	Meeting your company's financial criteria for capital investment		
*9.	Tax credits		
10.	The availability of process steam (or thermal energy) from the system		
11.	Protection against fuel curtailment		
*12.	Accelerated depreciation		
13.	Modularilty and relocatability of the system		
*14.	Loan guarantees		
15.	Lower operating costs than conventional systems		
16.	Easily fossil fired to achieve high capacity		
*17.	Low interest loans		
*18.	Land costs within your area		
19.	Usability of system to repower existing plants		
*20.	Reasonable exchanges with other utilities for selling excess/purchasing additional power		
21.	Busbar cost of electricity		

9. Based on your review of the presentation material and our discussion, keeping in mind your own company's needs and requirements, as well as the system's benefits and limitations, do you feel this system is an option your company would consider in the 1990 time period?

YES ☐ ASK 9a On next page

NO ☐ ASK 9b On next page

(IF YES)

9 a) Do you feel that the system most likely would be considered as (READ ALL)

An addition to your present generating capability ☐

A replacement for generation equipment now on line, or ☐

A system used to repower existing power plants ☐

(IF NOT)

9 b) What is the main reason you feel this system would not be considered? (PROBE FOR DETAIL) What other reasons? (PROBE FOR DETAIL)

10. In general, what is your reaction to the system as outlined? What benefits do you feel the system offers? What do you feel are its' limitations or drawbacks?

Benefits	Limitations
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

11. And what are the financial criteria your system would establish in evaluating a solar power system? (CHECK AND ESTABLISH PARAMETERS WHERE APPROPRIATE)

_____ Fixed charge rate _____%

_____ Return on investment _____%

_____ Payback period _____ years

_____ Other (SPECIFY)

ORIGINAL PAGE IS
OF POOR QUALITY

12. What is average price per acre of land suitable for Solar Power Systems in your area? _____

13. UTILITY NAME: _____

LOCATION (ADDRESS, CITY, STATE): _____

TYPE OF UTILITY: Private, Investor Owned ☐ ZIP: _____

REC ☐

OTHER ☐

GE ENGINEER: : _____

RESPONDENT: NAME: _____

TITLE: _____

ORIGINAL PAGE IS
OF POOR QUALITY

11636

ORIGINAL PAGE IS
OF POOR QUALITY

GENERAL ELECTRIC

THESE FORMS WERE USED IN MAIL SURVEYS

SOLAR POWER SYSTEMS UTILITY MARKET STUDY

1. Please record in the spaces provided below some information about your system characteristics.

a.	Current annual electricity sales		MWh
b.	Estimated annual electricity sales in 10 years		MWh
c.	Current peak demand		MW
d.	Estimated peak demand in 10 years		MW
e.	Percentage of requirements currently purchased		%
f.	Estimated percentage of requirements purchased in 10 years		%

IF YOUR UTILITY DOES NOT GENERATE, PLEASE GO TO QUESTION 3, PAGE 2

2a. What percentage of each equipment type is currently used in your generating mix?

b. And for each type of fuel you currently use, what do you feel the outlook is for 1990 in terms of availability and price changes?

PLEASE ANSWER A & B IN THE SPACES PROVIDED BELOW; WRITE IN PERCENT GENERATION MIX, CHECK ONE AVAILABILITY CATEGORY; INSERT TOTAL ANTICIPATED PRICE CHANGE UNDER +/- CATEGORY.

Equipment Type	A. Percent of Mix	B. 1990 Fuel Availability			Fuel Price Change Current to 1990 (%)	
		Unlimited	Partially Limited	Severely Limited	+	-
Nuclear	____	□	□	□	____	____
Hydro	____	□	□	□	____	____
Coal-Fired	____	□	□	□	____	____
Oil-Fired	____	□	□	□	____	____
Gas-Fired	____	□	□	□	____	____
Other (LIST)						
____	____	□	□	□	____	____
____	____	□	□	□	____	____
____	____	□	□	□	____	____

PLEASE ANSWER QUESTION 3 IF YOU PURCHASE ANY PART OF YOUR ELECTRICAL REQUIREMENTS. IF NOT, PLEASE SKIP TO QUESTION 4

3a. Please describe major problems which you may foresee in purchasing electrical power in 1990.

ORIGINAL PAGE IS
OF POOR QUALITY

3b. What total percentage price change do you anticipate in the cost of purchased electrical power between now and 1990?

\+ _____%

\- _____%

Extremely Likely	10
	9
	8
	7
	6
Moderately Likely	5
	4
	3
	2
	1
Not At All Likely	0

4a. Listed below are actions some utilities have mentioned as options for dealing with future energy requirements. Following the scale on the left, note the likelihood that your utility would take such action in the future, e.g. if you think that "Conversion to other fuel sources" is extremely likely, mark it 10; if not at all likely, mark it 0. Of course, you may use any number in between, and base your ratings on specific plans made by your utility or your own experience and judgment.

4b. If you have rated any of the alternative between "7" and "10", please give specific details. *E.G. WHAT FUELS ARE BEING REPLACED, BY WHAT?*

ACTIONS	4a LIKELIHOOD	4b DETAILS
I. Increase generating capabilities by: a. Addition of nuclear plants b. Addition of coal fired plants c. Addition of other fossil fired plants d. Other (SPECIFY) _____	____ ____ ____ ____	
II. Conversion to other fuel types:	____	
III. Purchase share in large units	____	
IV. Add energy storage: a. Pumped hydro b. Other	____ ____	
V. Purchase some or greater percentage of requirements	____	
VI. Other (SPECIFY) _____	____	

THIS PAGE WAS USED FOR REGION 1

The questions that follow refer to the solar energy concept you have already reviewed. As stated, in your particular solar area, the system requires 13 to 15 acres per megawatt, has a projected capital cost of $1300/KW, with a busbar energy cost of 6 to 7.5¢/kWh for electricity only; however if process heat credit is included this cost drops to 4 to 5.5¢/kWh. Costs are stated in 1979 dollars, and exclude land costs. Estimates are based on forty percent capacity factor from Solar input only.

Highest Rating	10
	9
	8
	7
	6
Average	5
	4
	3
	2
	1
Lowest Rating	0

5a. Please consider each item listed below in terms of its influence when your utility would consider a solar energy system. Following the scale on the left, rate each item on its influence. E. G. if you think that "Protection against fuel price escalation" would be extremely influential mark it 10; if not at all influential mark it 0. Of course you may use any number in between. Please rate each item below in the same way.

5b. And then, for each item listed which is not asterisked, please rate how well you think this particular solar system might meet your system's needs or requirements. This time a 10 means "Extremely Well" and a 0 means "Very Poor".

		5a. Influence in Consideration	5b. How Well Meets Needs
1.	Protection against fuel price escalation		
2.	Initial price of $1,300 per kilowatt		
3.	Appearance - aesthetics of the system		
*4.	Demonstrations of system operation in your solar region		
5.	Land requirements of 13 to 15 acres per megawatt		
6.	Your own company's energy policy		
7.	Pollution credits and/or meeting local standards		
8.	Meeting your company's financial criteria for capital investment		
*9.	Tax credits		
10.	The availability of process steam (or thermal energy) from the system		
11.	Protection anainst fuel curtailment		
*12.	Accelerated depreciation		
13.	Modularity and relocatability of the system		
*14.	Loan guarantees		
15.	Lower operating costs than conventional systems		
16.	Easily fossil fired for backup power and/or to achieve high capacity factor.		
*17.	Low interest loans		
*18.	Land costs within your area		
19.	Usability of solar system to repower existing steam turbine plants.		
*20.	Reasonable exchanges with other utilities for selling excess/purchasing additional power		
21.	Busbar cost of electricity		

ORIGINAL PAGE IS OF POOR QUALITY

ORIGINAL PAGE IS
OF POOR QUALITY

6a. Based on your review of the presentation material, keeping in mind your own system's needs and requirements, as well as the plant's benefits and limitations, do you feel this solar plant is an option your company would consider in the 1990 time period?

Yes ☐ Answer 6b

No ☐ Answer 6c

b. Do you feel that the plant most likely would be considered as:

An addition to your present generating capability ☐

A replacement for generation equipment now on line, or ☐

A system used to repower existing power plants ☐

c. What is the main reason you feel this plant would not be considered? What other reasons?

Main Reason

Other Reasons

7. In general, what is your reaction to the plant as outlined? What benefits do you feel the plant offers? What do you feel are its limitations or drawbacks?

Benefits

Drawbacks

ORIGINAL PAGE IS
OF POOR QUALITY

8. Please describe briefly the financial criteria your system would establish in evaluating a solar power plant. Include the items listed below and any other comments or criteria you wish.

Description/Comments	Criteria (Check if Appropriate) (✓)		
	____	Fixed charge rate	____%
	____	Return on investment	____%
	____	Payback period	____Years
	____	Other:	

9. What is the average price per acre of land in your area suitable for solar power systems?

$_____

Thank you for your help. Please fill in the following information about you and your company to help us classify your answers.

Type of Utility: _____

State: _____

Your Title: _____

Resposibilities: _____

If you would like a set of the Jupiter photos we mentioned in our letter, please fill in your name and mailing address below or send us a separate request.

Name: _____

Address: _____

City/State/Zip: _____

B-2. QUESTIONNAIRES FOR USE IN PERSONAL INTERVIEWS AND MAIL SURVEYS CONDUCTED WITH INDUSTRIAL FIRMS

ORIGINAL PAGE IS OF POOR QUALITY

GENERAL ELECTRIC

SOLAR POWER SYSTEMS INDUSTRIAL MARKET STUDY

THESE FORMS WERE USED IN PERSONAL INTERVIEWS

As we explained previously, I am here representing General Electric's Space Division and would like to discuss with you a product concept which you will probably find useful in your long range planning for energy needs.

First, I'd like to discuss briefly with you, your current and anticipated energy requirements.

1 . At this plant location, what is your annual electric consumption? a) And what do you anticipate that consumption to be in about 10 years? (RECORD BELOW)

2 . What is your current peak requirements? a) And about what would that be in 10 years? (RECORD BELOW)

ELECTRICAL CONSUMPTION

	CURRENT		10 YEARS
Q.1 ANNUAL CONSUMPTION	_____	Kwhr	_____
Q.2 PEAK REQUIREMENT	_____	MW	_____

3a . Do you use process steam in this plant:

Yes ☐

No ☐ SKIP TO Q.4

3b . At what pressures and in what quantities?

PRESSURES (PSI)	QUANTITIES (LBS/HR)
_____	_____
_____	_____
_____	_____

4 . About what percentage of your total electrical requirements are self-generated currently? a) And what would you estimate that percentage to be in 10 years?

Current _____%

10 Years _____%

IF NO SELF-GENERATION CURRENTLY, SKIP TO Q.8

[ASK Q.5-7 ONLY IF SOME PORTION OF ELECTRICAL REQUIREMENTS ARE SELF-GENERATED]

5 . a) What types of generation equipment are currently used? (RECORD BELOW) FOR EACH TYPE USED, ASK:

b) How many?

c) What sizes?

d) What type of fuel is used in each? (RECORD BELOW)

e) Which, if any, of these units are used as "standby" units only? (RECORD BELOW)

(RECORD DIFFERENT SIZES/FUEL TYPES INDIVIDUALLY)

	A) TYPE OF EQUIPMENT	B) NUMBER	C) SIZE	D) FUEL	E) STAND BY ONLY
1.					☐
2.					☐
3.					☐
4.					☐
5.					☐

5f . Is excess thermal energy from these units used to meet thermal needs of your plant?

YES ☐ ASK 5g.

NO ☐ SKIP TO Q.6

5g . (IF YES) How is this thermal energy used?

ORIGINAL PAGE IS
OF POOR QUALITY

6 . What is the primary reason for in-plant electrical generation. (READ LIST) If more than one of these reasons are applicable to your situation, please rank them ("1" being "Most Important") in order of their importance (RECORD BELOW)

REASONS	PRIMARY (one only)	RANK (if several apply)
Inexpensive fuel (SPECIFY TYPE)	☐	____
_____	☐	____
_____	☐	____
_____	☐	____
Generation is a by product of steam production	☐	____
Need for non-interruptable power supply	☐	____
Other (PLEASE SPECIFY)		
_____	☐	____
_____	☐	____
_____	☐	____
_____	☐	____

6b . Do you find it more expensive or less expensive to generate your own power as compared to purchasing it?

More Expensive to Generate ☐

Less Expensive to Generate ☐

6c . About what percentage differential is there in self-generated versus purchased power? _____%

ORIGINAL PAGE IS
OF POOR QUALITY

7 . Now, in reference to the fuels you are currently using, what do you feel the outlook is for the 1990 time period, in terms of both availability and price?

a) What about (FIRST FUEL TYPE)? Do you feel that the availability of (FUEL) will be unlimited, partially limited or severely limited? (RECORD BELOW)

b) And about what percentage price change (in total) do you anticipate between now and 1990 for (FUEL)?

(REPEAT A&B FOR EACH FUEL TYPE CURRENTLY USED. RECORD BELOW)

FUEL TYPE (SPECIFY)	AVAILABILITY - 1990			PRICE CHANGE CURRENT/1990 (%)	
	UNLIMITED	PARTIALLY LIMITED	SEVERELY LIMITED	+	-

ASK Q.8-9 IF PLANT'S ELECTRICAL'S NEEDS ARE NOT 100% SELF-GENERATED CURRENTLY: IF 100% SELF-GENERATED, SKIP TO Q.10

8a . And about the electric power you are currently purchasing, in about 1990 do you feel this source is unlimited and/or reliable, or do you see some possible problem? (IF PROBLEM, DEFINE)

UNLIMITED/RELIABLE _____

PROBLEM _____

PROBLEM AREAS:

8b . And about what percentage change do you anticipate in the cost of purchased electrical power between now and 1990?

+_____%

-_____%

ORIGINAL PAGE IS OF POOR QUALITY

ORIGINAL PAGE IS
OF POOR QUALITY

9a . Is there a specific reason why you do not generate some or greater proportion of your electrical requirements? What is that? (PROBE FOR DETAIL)

9b . Would you consider generation of some or a greater part of your electrical needs at this plant if purchase of your excess power by a utility were feasible?

YES ☐

NO ☐

ASK EVERYONE

10 . Several alternatives for dealing with future energy requirements have been mentioned as possibilities by companies such as yours. Please describe the likelihood of each of these being adopted by your plant between now and 1990. Use a scale running from "0" meaning "Not At All Likely" to "10" meaning "Extremely Likely". You may base this rating on either specific plans made by your company or your experience and judgment. (READ LIST)

ACTION	LIKELIHOOD _____
I. Adding or replacing existing equipment to expand or implement in-plant generation capabilities *[IF MODERATELY TO HIGHLY LIKELY, (LIKELIHOOD IS RATED 5 OR OVER) OBTAIN DETAILS]*	TYPE OF EQUIPMENT: _____ NUMBER _____ SIZE _____
II. (ASK ONLY IF CURRENTLY GENERATING) Conversion to other fuel sources *[IF MODERATELY TO HIGHLY LIKELY, (LIKELIHOOD IS RATED 5 OR OVER) OBTAIN DETAILS]*	LIKELIHOOD _____ FROM: _____ TO: _____
III. Purchase a greater proportion of electrical needs	LIKELIHOOD _____
IV. No action -	LIKELIHOOD _____

THIS PAGE WAS USED FOR REGION 2

11. Now, I would like to discuss with you the solar energy concept you have already reviewed. As stated, in your particular solar area, the system requires 10 to 12 acres per megawatt has a projected capital cost of $1100/KW, with a delivered energy cost of 7 to 8¢/KW for electricity only; however, if process heat credit is included this cost drops to 5 to 6¢/KW. Costs are stated in 1979 dollars, and exclude land costs. Estimates are based on forty percent capacity factor from Solar input only.

a) I have here some items that may or may not affect consideration of a solar system such as this by a company like yours. As I read each item, please tell me how influential you feel it would be when considering a solar energy system by rating that item on a scale from "0" meaning "Not At All Influential" to "10" meaning "Extremely Influential".

b) And for some of those items that I will mention, please tell me how well this particular solar system might meet your company's needs or requirements. This time "0" will mean "Very Poor" and "10" will mean "Extremely Well". (DO NOT ASK "B" FOR * STATEMENTS)

	11a INFLUENCE IN CONSIDERATION	11b HOW WELL MEETS NEEDS
1. Protection against fuel price escalation	_____	_____
2. Initial price of $1,100 per kilowatt	_____	_____
3. Appearance - aesthetics of the system	_____	_____
*4. Demonstrations of system operation in your solar region	_____	[redacted]
5. Land requirements of 10 to 12 acres per megawatt	_____	_____
6. Your own company's energy policy	_____	_____
7. Pollution credits and/ or meeting local standards	_____	_____

ORIGINAL PAGE IS
OF POOR QUALITY

THIS PAGE WAS USED FOR REGION 2

ORIGINAL PAGE IS
OF POOR QUALITY

		10a INFLUENCE IN CONSIDERATION	10b HOW WELL MEETS NEEDS
8.	Meeting your company's financial criteria for capital investment		
*9.	Tax credits		
10.	The availability of process steam (or thermal energy) from the system		
11.	Protection against fuel curtailment		
*12.	Accelerated depreciation		
13.	Modularilty and relocatability of the system		
*14.	Loan guarantees		
15.	Lower operating costs than conventional systems		
16.	Easily fossil fired to achieve high capacity		
*17.	Low interest loans		
*18.	Land costs within your area		
19.	Usability of system to repower existing plants		
*20.	Reasonable exchanges with local utilities selling excess/purchasing additional power		
21.	Delivered cost 7-8¢ per kilowatt hour of electricity (excluding process steam credit)		

12. Based on your review of the presentation material and our discussion, keeping in mind your own company's needs and requirements, as well as the system's benefits and limitations, do you feel this system is an option your company would consider in the 1990 time period?

YES ☐ ASK 12a

NO ☐ ASK 12b

ORIGINAL PAGE IS
OF POOR QUALITY

(IF YES)

a) Do you feel that the system most likely would be considered as (READ ALL)

An addition to your present generating capability ☐

A replacement for generation equipment now on line, or ☐

A system used to repower existing power plants ☐

(IF NOT)

b) What is the main reason you feel this system would not be considered? (PROBE FOR DETAIL) What other reasons? (PROBE FOR DETAIL)

13. In general, what is your reaction to the system as outlined? What benefits do you feel the system offers? What do you feel are its limitations or drawbacks?

Benefits	Limitations
_____	_____
_____	_____
_____	_____
_____	_____

14. *[ASK/DISCUSS ONLY IF STRONG RESERVATIONS/OBJECTION TO COST FACTORS IN Q.11 ARE NOTED]*

What would your company consider a fair price per megawatt (exluding land acquisition costs) for a solar power plant? (EXPLORE FULLY)

15. What is the average price per acre of industrial land in your area?

$_____

ORIGINAL PAGE IS
OF POOR QUALITY

COMPANY NAME:_____

LOCATION (ADDRESS, CITY, STATE)_____

TYPE OF BUSINESS:_____

SIC ____ ____ ____ ____ DSO ACCOUNT #____ ____ ____ ____ ____ ____ ____

SALES ENGINEER:_____

RESPONDENT: NAME:_____

TITLE:_____

GENERAL ELECTRIC
SOLAR POWER SYSTEMS INDUSTRIAL SURVEY

THESE FORMS WERE USED IN MAIL SURVEYS

1. Please record in the spaces provided below some information about your company's electrical requirements:

a.	Current annual electric consumption		kWh
b.	Estimated annual electric consumption in 10 years		kWh
c.	Peak requirements		KW
d.	Estimated peak requirement in 10 years		KW
e.	Process steam: Pressure required		PSIA
f.	Process steam: Maximum quantity required		LBS/HR
g.	Percentage of total electric requirement currently generated in-plant		%
h.	Percentage estimated to be generated in-plant in 10 years		%

IF YOUR COMPANY DOES NOT CURRENTLY GENERATE ANY OF ITS OWN ELECTRICITY, PLEASE GO TO QUESTION 5, PAGE 3

2. List below all generation equipment currently on line in your plant location. Include the number you have, the size of each, and the type of fuel used in each. Indicate which, of any, of this equipment is "standby" only.

Type of Equipment	Number of Units	Size of Unit	Fuel	Check (✓) Below if Standby Only

ORIGINAL PAGE IS
OF POOR QUALITY

3 . Please indicate below the primary reason for in-plant generation in your location. Do this by placing a "1" next to that reason. If more than one reason is applicable to your situation, continue to rank (2, 3, etc.) those reasons.

Reason	Rank Order of Importance
Inexpensive fuel (TYPE): _____	_____
Generation is a by product of steam production	_____
Need for non-interruptible power supply	_____
In-plant generation less expensive than purchased electricity	_____
Other (PLEASE SPECIFY) _____ _____ _____	_____

4 . For the fuel or fuels you currently use, what do you feel the outlook is for 1990, in terms of availability and price changes.
ANSWER IN SPACE BELOW

FUEL TYPE	AVAILABILITY - 1990 (CHECK ONE)			PRICE CHANGE CURRENT TO 1990 (%)	
	UNLIMITED	PARTIALLY LIMITED	SEVERELY LIMITED	+	-
Oil	□	□	□	_____	_____
Coal	□	□	□	_____	_____
Gas	□	□	□	_____	_____
Hydro	□	□	□	_____	_____
Other: LIST _____	□	□	□	_____	_____

PLEASE ANSWER QUESTIONS 5 AND 6 IF YOU PURCHASE ANY PART OF YOUR ELECTRICAL REQUIREMENTS. IF NOT, PLEASE SKIP TO QUESTION 7

5a. Please describe any problems which you may foresee in purchasing electrical power in 1990?

ORIGINAL PAGE IS
OF POOR QUALITY

5b. What total percentage price change do you anticipate in the cost of purchased electrical power between now and 1990?

+_____%

-_____%

6a. What is the reason you do not generate some or a greater proportion of your electrical requirements?

6b. Would you consider generation of some or a greater part of your electrical needs at this plant if purchase of your excess power by a utility were feasible?

Yes ☐

No ☐

Highest Rating	10
	9
	8
	7
	6
Average	5
	4
	3
	2
	1
Lowest Rating	0

7a. Listed below are three actions some companies have mentioned as options for dealing with future energy requirements. Following the scale on the left, rate the likelihood that your company would take such action in the future. E.G. if you think that "Conversion to other fuel sources" is extremely likely, mark it 10; if not at all likely, mark it 0. Of course you may use any number in between and base your ratings on specific plans made by your company or your own experience and judgment.

7b. If you have rated any of the alternatives between "7" and "10", please give specific details. *E.G. WHAT TYPE OF EQUIPMENT IS TO BE ADDED, WHAT FUELS ARE BEING REPLACED, BY WHAT?*

7a 7b

ACTION	LIKELIHOOD	DETAILS
Adding or replacing existing equipment to expand or implement in-plant generation equipment		
Conversion to other fuel sources		
Purchase a greater proportion of electrical needs		

THIS PAGE WAS USED FOR REGION 2

The questions that follow refer to the solar energy concept you have already reviewed. As stated, in your particular solar area, the system requires 10 to 12 acres per megawatt, has a projected capital cost of $1100/KW, with a delivered energy cost of 7 to 8¢/kWh for electricity only, however; if process heat credit is included, this cost drops to 5 to 6¢/kWh. Costs are stated in 1979 dollars, and exclude land costs. Estimates are based on forty percent capacity factor from Solar input only.

Highest Rating	10
	9
	8
	7
	6
Average	5
	4
	3
	2
	1
Lowest Rating	0

8a. Please consider each item listed below in terms of its influence when your company would consider a solar energy system. Following the scale on the left, rate each item on its influence. E. G. if you think that "Protection against fuel price escalation" would be extremely influential mark it 10; if not at all influential mark it 0. Of course you may use any number in between. Please rate each item below in the same way.

8b. And then, for each item listed which is not asterisked, please rate how well you think this particular solar system might meet your company's needs or requirements. This time a 10 means "Extremely Well" and a 0 means "Very Poor".

		8A INFLUENCE IN CONSIDERATION	8B HOW WELL MEETS NEEDS
1.	Protection against fuel price escalation		
2.	Initial price of $1,100 per kilowatt		
3.	Appearance - aesthetics of the system		
*4.	Demonstrations of system operation in your solar region		
5.	Land requirements of 10 to 12 acres per megawatt		
6.	Your own company's policy		
7.	Pollution credits and/or meeting local standards		
8.	Meeting your company's financial criteria for capital investment		
*9.	Tax credits		
10.	The availability of process steam (or thermal energy) from the system		
11.	Protection against fuel curtailment		
*12.	Accelerated depreciation		
13.	Modularity and relocatability of the system		
*14.	Loan guarantees		
15.	Lower operating costs than conventional systems		
16.	Easily fossil fired to achieve high capacity		
*17.	Low interest loans		
*18.	Land costs within your area		
19.	Usability of system to repower existing plants		
*20.	Reasonable exchanges with local utilities selling excess/purchasing additional power		
21.	Delivered cost 7-8¢ per kilowatt hour of electricity (excluding process steam credit)		

ORIGINAL PAGE IS OF POOR QUALITY

9a. Based on your review of the presentation material keeping in mind your own company's needs and requirements, as well as the system's benefits and limitations, do you feel this system is an option your company would consider in the 1990 time period?

Yes ☐ Answer 9b

No ☐ Answer 9c

b. Do you feel that the system most likely would be considered as:

An addition to your present generating capability ☐

A replacement for generation equipment now on line, or ☐

A system used to repower existing power plants ☐

c. What is the main reason you feel this system would not be considered? What other reasons?

Main Reason

Other Reasons

ORIGINAL PAGE IS
OF POOR QUALITY

10. In general, what is your reaction to the system as outlined? What benefits do you feel the system offers? What do you feel are its limitations or drawbacks?

Benefits

Drawbacks

11. Please describe briefly the financial criteria your company would establish in evaluating a solar power system. Include the items listed below and any other comments or criteria you wish.

Description/Comments	Criteria (Check if Appropriate) (✓)		
	____	Return on investment	____%
	____	Payback period	____Years
	____	Other: _____	____

12. What is the average price per acre of industrial land in your area?

$_____

Thank you for your help. Please fill in the following information about you and your company to help us classify your answers.

Type of Business or Industry: _____

SIC Classification: ____ ____ ____ ____

State: _____

Your Title: _____

Responsibilities: _____

If you would like a set of the Jupiter photos we mentioned in our letter, please fill in your name and mailing address below or send us a separate request.

Name: _____

Address: _____

City/State/Zip: _____

ORIGINAL PAGE IS
OF POOR QUALITY

11604

B-3. QUESTIONNAIRES USED IN SURVEY OF DESIGN ENGINEERING FIRMS

ORIGINAL PAGE IS
OF POOR QUALITY

GENERAL ELECTRIC

SOLAR POWER SYSTEMS DESIGN FIRM SURVEY

1. In your opinion, what features of the Solar Power Systems (SPS), as presented, would be important to prospective users?

	Very Important	Important	Not Important
Energy cost savings			
Energy curtailment protection			
Ability to fossil fire for back-up and/or high capacity factor			
Availability of process steam			
System modularity			
Pollution reduction			
Other _____			

	Major Drawback	Drawback	Minor Effect
2. What are the principal drawbacks, or barriers, that you feel might restrict acceptance of SPS?			
Initial cost			
Land area requirements			
Sun variability			
Technical complexity			
Other _____			

ORIGINAL PAGE IS
OF POOR QUALITY

3. Are there particular applications for which you feel SPS might be more suitable than others?

No_____

Yes_____

Types: _____ _____ _____

Reasons: _____ _____ _____

4. Does the international market have any characteristics different from the domestic market that would affect user acceptance of these systems?

Land availability _____

Land costs _____

Energy prices and availability _____

Ownership characteristics _____

Government policies _____

National goals _____

5. Which of the system types presented do you feel has the most potential for non-utility applications?

Central generation

Distributed generation

Reason:

ORIGINAL PAGE IS
OF POOR QUALITY

6. Cogeneration of electricity and process steam has seen little application in the domestic electric utility sector. Based on your experience, do foreign utility systems have any characteristics that make cogenerating power systems more attractive to them?

 No___

 Yes___ _____

7. Land costs obviously have a strong affect on total cost of a Solar Power System. What is the approximate range of land costs (if available) that your firm has encountered in recent projects?

		$/Acre	Region
Domestic	- Low	_____	_____
	- High	_____	_____
International	- Low	_____	_____
	- High	_____	_____

8. Briefly (and candidly) what is your overall reaction to the Solar Power Systems presented?

ORIGINAL PAGE IS
OF POOR QUALITY

Thank you for your help. Please fill in the following information about you and your company to help us classify your answers.

Type of Business_____

Design Specialties_____

Your Title:_____

Responsibilities:_____

If you would like a set of the Jupiter photos we mentioned in our letter, please fill in your name and mailing address below or send us a separate request.

Name: _____

Address:_____

City/State/Zip:_____

APPENDIX C

SPS MARKET DEMAND COMPUTER PROGRAM

APPENDIX C

SPS COMPUTER DEMAND MODEL

The solar power systems economic demand computer program was written to be run in an interactive, time-sharing mode on the Honeywell 666/DPS computer. Input data files are brought into the available file table for program access by a first line RUN command. A run is then initiated by entering FRN/DEMAND/SPS.

The program is divided into three main sections: a data input section, computational loops for each state and SIC or utility type, and a data output section. In the data input section, the following data is read from files:

- solar insolation ($kWh/m^2/day$) - for each state
- energy price (¢/kWh) - for each SIC, state combination
- fuel price (¢/kWh) - for each utility type in each state
- energy demand (kWh/yr) - for each SIC, utility type, state

Solar insolation is taken from the data of Figure 2-16, while energy prices and demand are from Survey of Manufactures and Edison Electric Institute data. SPS interview and survey data is input as statistical distributions for the following parameters:

- industrial land costs
- utility land costs
- required industrial return on investment
- utility fixed charge rates
- system acceptance data

Individual input data items are divided into two sets, the first consisting of those items most likely to be varied in parametric studies. These include:

SYSCST - system cost - $/kW
PRICYR - year for SYSCST dollars (1980 for all runs)
STARYR - system start year
ELEINF - electricity price escalation - decimal
FULINF - utility fuel price escalation - decimal
INDINF - land price inflation - decimal
GINF - general inflation level - decimal
REQLND - SPS land requirements - acres/MW

Electricity, fuel and land price escalations are in real terms, i.e., over and above general inflation. The above variables comprise the file "CHANGE" which can be varied by the program user at the terminal keyboard.

A second set of input data consists of items normally fixed throughout the analysis. These include parameters defining the size of the various data files and reference years for the energy price and consumption data of the input files. Parameters defining the shape of the Fisher-Pry market penetration curves are contained in this data block, along with assumed energy consumption growth rates. At the end of the data input, the user is given the option to redefine any of the variables in the "CHANGE" file.

Instructions and an example of how to change variables are printed out at the terminal. The user also, at this point, has the option of having the entire "CHANGE" file printed.

After the data files have been read, the main loops on each state (outer loop) and SIC (inner loop) are started. [Dummy SIC values were assigned to investor-owned utilities (SIC 83) and non-investor-owned utilities (SIC 93)]. Computations begin with SPS system capacity factor by state as a function of insolation level. Electricity price, for each state and SIC, is updated to the start year.

System savings and return on investment (or fixed charge rate for utilities) are then computed. This is done first for zero land cost with the result checked against the minimum value in the ROI (or FCR) distribution file, to determine if any of the potential sector market is economically viable. If this initial screen is met, calculations are then made for each land cost in the appropriate land cost distribution file, with resulting ROI (or FCR) compared to values in the ROI (or FCR) distribution file.

The economic market potential for each SIC and state is modified by the system acceptance data file to yield the market fraction who would: (1) consider the system as an option; and (2) consider the system economic or meeting their investment criteria. Application of the Fisler-Pry market penetration algorithm to the projected economic market yields the SPS market potential at any point in time.

The output section provides a listing of market size (in MW), percent penetration, and electricity cost (1980 //kWh) for each state/SIC combination indicating market potential. In addition, a breakdown of market by SIC and total SPS market are printed.

After the output is completed, the program can be rerun by responding "Y" to the question "AGAIN?". When all program runs are completed, the user is given the option of retaining recent data inputs in the "CHANGE" file.

A marked-up sample program run follows, along with a program listing. Input data file contents are not listed due to the confidentiality of those that came from the interview/survey effort.

ORIGINAL PAGE IS
OF POOR QUALITY

```
*FRN /DEMAND/SPS

        12/19/80    10.385

INPUT DATA IN THE FOLLOWING FORM.
EXAMPLE:  $CHANGE SYSCST=1500., STARYR=1992 $

IF THERE ARE NO CHANGES, INPUT $CHANGE $
=$CHANGE STARYR=1990, SYSCST=1000., ELEINF=0.02, FULINF=0.02 $
DO YOU WANT TO SEE THE INPUT? (Y OR N)
=Y
$INPUT
ELEINF=    0.20000000E-01,   LNDINF=    0.10000000E-01,
STARYR=          1990,   PRICYR=  .          1980,
SYSCST=    0.10000000E 04,   REALND=    0.10000000E 02,
GINF  =    0.80000000E-01,   FULINF=    0.20000000E-01,
$END$INPUT

MARKET BREAKDOWN BY STATE & SIC

ST.  SIC    MKT.(MWE)     % PENTR.     ELEC. PRICE(CTS./KWH)
VT   83   0.415E 00     0.2697      5.3506
VT   93   0.528E 01     6.8149      5.3506
MA   93   0.347E-03     0.0007      3.0107
RI   83   0.491E-02     0.0013      4.0714
CT   93   0.330E-01     0.0454      3.4631
NY   93   0.152E-01     0.0012      3.2135
NJ   93   0.139E 00     0.0887      3.5255
IN   31   0.766E-03     0.0030      9.5312
AR   93   0.838E 01     1.8140      3.2291
OK   93   0.142E-01     0.0012      2.2151
ID   83   0.440E 00     0.6167      3.8842
AZ   20   0.376E-01     0.0688      5.5086
AZ   23   0.719E-02     0.0763      5.5846
AZ   27   0.302E 00     2.0109      7.3473
AZ   29   0.194E-03     0.1052      5.7250
AZ   32   0.126E 00     0.1921      5.7718
AZ   37   0.596E-02     0.0120      5.3662
AZ   93   0.100E 01     0.0177      1.7471
NV   20   0.139E 00     1.0672      7.2381
NV   27   0.686E-02     0.1144      6.5049
NV   32   0.370E 00     0.8112      7.1913
NV   35   0.547E-01     3.2738      9.3596
OR   83   0.215E 01     0.1568      5.0854
OR   93   0.711E 01     6.5621      5.0854
CA   23   0.256E 00     0.2822      6.8013
CA   83   0.222E 04     7.3318      4.0714
CA   93   0.467E 03     7.1522      4.0714
AL   93   0.542E-03     0.0001      3.2915
HI   20   0.573E-01     0.1096      6.2553
HI   26   0.359E-01     6.3438     11.4187
HI   32   0.174E 00     1.0132      7.1133
HI   93   0.131E 03     6.9949      3.6971

BREAKDOWN OF TOTAL MARKET(FOR ALL STATES) BY SICS

          SIC       MKT(MWE)
          20        0.234E 00
          23        0.263E 00
          26        0.359E-01
          27        0.309E 00
          29        0.194E-03
          31        0.766E-03
          32        0.670E 00
          35        0.547E-01
          37        0.596E-02
          83        0.235E 04
          93        0.489E 03

  0.29405931E 04= THE TOTAL MARKET (FOR ALL SICS & ALL STATES)
AGAIN? (Y OR N)
=N
DO YOU WANT TO RESAVE THE MOST RECENT $CHANGE DATA? (Y OR N)
=N
```

USER'S RESPONSE

INSTRUCTIONS & EXAMPLE ON REDEFINING "CHANGE" NAMELIST VARIABLES.

USER'S RESPONSE

OPTION TO HAVE "CHANGE" LISTED.

NAMELIST PRINTOUT

OUTPUT

USER'S RESPONSE

OPTION TO RERUN PROGRAM

OPTION TO SAVE MOST RECENT "CHANGE" DATA

```
10*#RUNH *#"04";/ARRAY/PRICELOW"08";/ARRAY/PRICEHI"19";                    FILENAME  -  1E700636/DEMAND/SPS
20*#/PJ/DIRECTIN"11";/PJ/UTLAND"14";
30*#/PJ/INDLAND"13";/PJ/INDROI"15";/PJ/UTINVFCR"16";
40*#/DEMAND/STAY"17";/DEMAND/CHANGE"43";/PJ/UTILCAP"09";
50*#/ARRAY/ENGDEMLO"30";/ARRAY/ENGDEMM1"27";/DEMAND/ISSYSOPT"21";
60*#/ARRAY/ENGDEMM2"31";/ARRAY/ENGDEMHI"29"
70C
80C******/DEMAND/SPS  --- A PROGRAM TO TEST THE ECONOMICS OF A SOLAR SYSTEM
90C
100C*****SOLAR POWER SYSTEM DEMAND MODEL
110C*****
120C*****WRITTEN BY K. MASSEY      9AM 2 JAN 80
130C*****CHANGED BY P. STRAUS     4PM 29  FEB 80
140C$$$$ REVISED BY D.B. SHAMIS  4-80 & 12-80
150C
160C$$$$ PARAMETER DEFINITIONS:
170C           NSIC=NUMBER OF SICS INCLUDING UTILITY(NON-STANDARD) SICS
180C           MAXGRP=THE MAXIMUM NUMBER OF ROI OR LAND COST GROUPS
190 PARAMETER NSIC=25,MAXGRP=30
200C
210 CHARACTER*1 ANSWER
220 CHARACTER*2 STABRV(50)
230 LOGICAL FIRST
240 INTEGER PRICYR,STARYR,ECONYR,HOWLNG(50,NSIC),NUMCUM(MAXGRP),NUMBER(MAXGRP)
250 &       ,CONSYR,ELECYR,FUELYR,CAPYR,HALFPN,ACTSIC(25),YES,YSUM
260 REAL LNDINF,LOADFC,LANDCT,LEVELC,LEVSAV,MKT,ICONGR,IPCT
270 &      ,CUMFRI,PRICE(50,NSIC),FRLNDU(MAXGRP),FRLNDI(MAXGRP)
280 &       ,LCSIND(MAXGRP),LCSUTL(MAXGRP),FCR(MAXGRP)
290 &       ,INDLND,SICAVG(NSIC),AVGSTP(50),INDMAX,UTLMAX,REALCONV,MKTSUM
300 &       ,MKTSIC(NSIC)
310C
320 COMMON /FIRST/ FREQ(MAXGRP),MKT(50,NSIC),ENGDEM(50,NSIC),UTLDEM(50,NSIC),
330 &              ENGESC(NSIC),ELECPY(50,NSIC),LCS(MAXGRP),LC(NSIC),
340 &              LOADFC(NSIC),FULCPY(50),FULPRICE(50)
350 COMMON /SECOND/ICONGR(MAXGRP),ROI(MAXGRP),UCONGR(MAXGRP),
360 &              DF(NSIC),FCR,
370 &              CUMFRU(MAXGRP),CUMFRI(MAXGRP),
380 &              STAINS(50),STAVG(50),SDMAX(50,NSIC),STSUM(50)
390C
400 NAMELIST /CHANGE/ INDMAX,UTLMAX,DISCUT,HZNUTL,ELEINF,LNDINF,
410 &                 STARYR,PRICYR,DISCNT,HORIZN,SYSCST,
420 &                 REQLND,GINF,FULINF
430 &                ,HALFPN,SHAPE
440 &                 ,CONSTLD,CONSTESC
450 NAMELIST /INPUT/ ELEINF,LNDINF,STARYR,PRICYR,SYSCST,REQLND,GINF,
460 &                FULINF
470 NAMELIST /STAY/ INVUTL,NROI,NGROUP,MGROUP,NFCR,
480 &               CONSYR,ELECYR,FUELYR,LANDYR,CAPYR,UPDATE,
490 &               REFCAP,REFINS,TAXRAT
500C$$$$ FIRST IS USED TO BYPASS PRINTOUT OF TITLE AFTER FIRST TIME THROUGH
510C$$$$ THE DO 700 LOOP
520       FIRST=.TRUE.
530C
540C$$$$ DEFINE AN ARRAY ACTSIC WHICH CONTAINS ACTUAL SIC NUMBERS
550       DATA ACTSIC/20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,
560 &              37,38,39,43,53,63,83,93/
570C
580C$$$$ REALCONV IS A VARIABLE USED TO CHANGE INTEGER DIVISION TO
590C      REAL DIVISION.
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
600 REALCONV=1.0
610C
620C$$$$ READ THE NAMELIST DATA FILES.
630 READ(17,STAY)
640 READ(43,CHANGE)
650C
660C$$$$ READ FROM DATA FILE THE AVERAGE INSOLATION LEVEL(KWH/SQ. MTR./DAY)
670C      FOR EACH STATE.
680 READ(11,1011)STAINS
690 1011 FORMAT(V)
700C
710C$$$$ READ ISTATE(WHICH EQUALS I), STATE ABBREVIATION(A CHARACTER
720C      VARIABLE USED IN THE OUTPUT), AVGSTP(AVG. PRICE FOR STATE INCLUDING
730C      UNLISTED SICS), AND THE ENERGY PRICE(CENTS/KWH) FOR SICS 20 THROUGH 53
740C      FOR ALL STATES.
750     DO 22222 I=1,50
760       READ (8,831) ISTATE,STABRV(ISTATE),AVGSTP(ISTATE),
770       &         (PRICE(ISTATE,JSIC),JSIC=1,11)
780       READ (19,831) ISTATE,STABRV(ISTATE),AVGSTP(ISTATE),
790       &         (PRICE(ISTATE,JSIC),JSIC=12,20),
800       &         (PRICE(ISTATE,JSIC),JSIC=21,22)
810       831 FORMAT (V)
820     22222 CONTINUE
830C
840C$$$$ SET SIC 63(UNCATAGORIZED INDUSTRIES) ENERGY PRICE EQUAL TO THE
850C      AVERAGE VALUE OF ENERGY PRICE FOR ALL OTHER INDUSTRIAL SICS.
860 DO 3232 ISTATE=1,50
870     STAVG(ISTATE)=0.
880     DO 2323 JSIC=1,22
890       STSUM(ISTATE)=PRICE(ISTATE,JSIC)+STSUM(ISTATE)
900     2323 CONTINUE
910     STAVG(ISTATE)=STSUM(ISTATE)/22.
920 3232 CONTINUE
930C$$$$ IF NEITHER SIC 43(FERROUS METALS) NOR SIC 53(NON-FERROUS METALS)
940C      ARE GIVEN, THEN USE SIC 33(PRIMARY METALS) ENERGY PRICES FOR BOTH.
950C
960 DO 4800 ISTATE =1,50
970       IF (ABS(PRICE(ISTATE,21) + PRICE(ISTATE,22)) .GT. .001)
980      &  GO TO 4799
990C
1000                PRICE(ISTATE,21)=PRICE(ISTATE,14)
1010                PRICE(ISTATE,22)=PRICE(ISTATE,14)
1020       4799 CONTINUE
1030C
1040C$$$$ USE THE AVERAGE ENERGY PRICE FOR THE STATE AS THE SIC 63
1050C      (UNKNOWN INDUSTRIES) ENERGY PRICE.
1060 PRICE(ISTATE,23)=AVGSTP(ISTATE)
1070 4800 CONTINUE
1080C
1090C$$$$ COMPUTE ELECTRIC PRICE IN THE BASELINE YEAR FOR THE INDUSTRIAL SECTOR.
1100C      (INVUTL, THE DO 5700 UPPER LOOP LIMIT +1, INDICATES THE STARTING
1110C      POSITION OF UTILITIES IN ARRAYS USED IN THE PROGRAM)
1120 DO 5800 ISTATE=1,50
1130       DO 5700 JSIC=1,INVUTL-1
1140            ELECPY(ISTATE,JSIC)=PRICE(ISTATE,JSIC)*UPDATE
1150       5700 CONTINUE
1160 5800 CONTINUE
1170C
1180C
1190C$$$$ START INDUSTRIAL LAND COST SECTION.
1200C$$$$ READ THE TABLE OF INDUSTRIAL LAND COSTS (THOUSAND $/ACRE), AND
```


ORIGINAL PAGE IS
OF POOR QUALITY

```
1210C     THE CORRESPONDING NUMBER OF RESPONDENTS TO WHICH EACH COST APPLIES.
1220 READ(13,1013) (LCSIND(LGROUP),NUMBER(LGROUP), LGROUP=1,NGROUP)
1230 1013 FORMAT(V)
1240 NUMTOT = 0
1250 INDLND=0.
1260C
1270C     COMPUTE THE TOTAL LAND COST & THE TOTAL NUMBER OF RESPONDENTS
1280C     FOR ALL LAND GROUPS(COST LEVELS).
1290 DO 2013 LGROUP=1,NGROUP
1300      NUMTOT=NUMTOT+NUMBER(LGROUP)
1310       INDLND=INDLND + NUMBER(LGROUP)*LCSIND(LGROUP)
1320 2013 CONTINUE
1330C$$$$ COMPUTE THE AVERAGE LAND COST PER RESPONDENT.
1340 INDLND =INDLND/NUMTOT
1350C$$$$ COMPUTE THE FRACTION OF RESPONDENTS AT EACH LAND COST LEVEL.
1360 DO 3013 LGROUP=1,NGROUP
1370      FRLNDI(LGROUP) = REALCONV*NUMBER(LGROUP)/NUMTOT
1380 3013 CONTINUE
1390C
1400C$$$$ START UTILITY LAND COST SECTION.
1410C$$$$ REPEAT PROCESS DESCRIBED ABOVE FOR INDUSTRIAL FIRMS FOR THE UTILITIES.
1420 READ(14,1014) (LCSUTL(LGROUP),NUMBER(LGROUP), LGROUP=1,MGROUP)
1430 1014 FORMAT(V)
1440 NUMTOT = 0
1450 DO 4013 LGROUP=1,MGROUP
1460      NUMTOT=NUMTOT+NUMBER(LGROUP)
1470 4013 CONTINUE
1480C
1490 DO 3014 LGROUP=1,MGROUP
1500      FRLNDU(LGROUP) = REALCONV*NUMBER(LGROUP)/NUMTOT
1510 3014 CONTINUE
1520C
1530C$$$$ START INVESTMENT REQUIREMENT SECTION FOR INDUSTRIAL SECTOR.
1540C$$$$ READ DATA FILE WHICH LISTS THE NUMBER OF RESPONDENTS AT EACH
1550C     CORRESPONDING REQUIRED ROI.  THE FILE IS SET UP WITH THE MINIMUM
1560C     ROI IN ROW 1 & THE MAXIMUM ROI IN ROW NROI.
1570 READ(15,1015) (NUMBER(IROI),ROI(IROI), IROI=1,NROI)
1580 1015 FORMAT(V)
1590 NUMCUM(1)=NUMBER(1)
1600 ORATIO=3./4.
1610 ROIMIN=ROI(1)
1620C$$$$ COMPUTE THE CUMULATIVE NUMBER OF RESPONDENTS FOR EACH "MAXIMUM"
1630C     REQUIRED ROI.  (THE NUMBER OF RESPONDENTS WHO REQUIRE THE
1640C     CORRESPONDING ROI OR LESS)
1650 DO 2015 IROI=2,NROI
1660      NUMCUM(IROI)=NUMCUM(IROI-1) + NUMBER(IROI)
1670 2015 CONTINUE
1680C$$$$ COMPUTE THE FRACTION OF RESPONDENTS WHO REQUIRE THE
1690C     CORRESPONDING ROI OR LESS.
1700 DO 3015 IROI=1,NROI
1710      CUMFRI(IROI)=REALCONV*NUMCUM(IROI)/NUMCUM(NROI)
1720 3015 CONTINUE
1730C
1740C$$$$ START SECTION ON INVESTMENT REQUIREMENTS FOR UTILITIES.
1750C$$$$ REPEAT PROCESS DESCRIBED ABOVE USING FIXED CHARGE RATE INSTEAD
1760C     OF ROI.
1770 READ(16,1016) (NUMBER(IFCR),FCR(IFCR), IFCR=1,NFCR)
1780 1016 FORMAT(V)
1790 NUMCUM(1)=NUMBER(1)
1800 FCRMIN=FCR(1)
1810 DO 2015 IFCR=2,NFCR
```


ORIGINAL PAGE IS
OF POOR QUALITY

```
      NUMCUM(IFCR)=NUMCUM(IFCR-1) + NUMBER(IFCR)
 2016 CONTINUE
      DO 3016 IFCR=1,NFCR
      CUMFRU(IFCR)=REALCONV*NUMCUM(IFCR)/NUMCUM(NFCR)
 3016 CONTINUE
C
C$$$$ READ FROM DATA FILE THE NUMBER OF RESPONDENTS FROM EACH SIC
C     WHO WOULD CONSIDER A SOLAR POWER SYSTEM AS AN OPTION.
C     USING THIS DATA COMPUTE A DILUTION FACTOR FOR EACH SIC.
C     IF THE TOTAL NUMBER OF REPLIES FOR A GIVEN SIC IS LESS THAN 7,
C     THEN THE SAMPLE IS CONSIDERED TOO SMALL & AN AVERAGE VALUE
C     (BASED ON ALL REPLIES)IS USED FOR THAT SIC.
      YSUM=0
      NSUM=0
      DO 10021 JSIC=1,NSIC
      READ (21,1021) A,NO,YES
 1021 FORMAT (V)
      YSUM=YSUM+YES
       NSUM=NSUM+NO
      IF (NO + YES .LT. 7) GO TO 20021
           DF(JSIC)=REALCONV*YES/(YES+NO)
           GO TO 10021
20021 CONTINUE
      DF(JSIC)=-1
10021 CONTINUE
      DFAVG=REALCONV*YSUM/(YSUM+NSUM)
      DO 30021 JSIC=1,INVUTL-1
      IF (DF(JSIC) .LT. 0) DF(JSIC)=DFAVG
30021 CONTINUE
C
C$$$$ READ ENERGY DEMAND (MWE) OF INDUSTRIAL CLASSIFICATIONS IN EACH STATE.
      READ (30,8851)
      READ (27,8851)
      READ (31,8851)
      READ (29,8851)
 8851 FORMAT (1X)
      DO 345 ISTATE=1,50
C
      READ (30,8831)
      &         (ENGDEM(ISTATE,JSIC),JSIC=1,7)
      READ (27,8831)
      &         (ENGDEM(ISTATE,JSIC),JSIC=8,14)
      READ (31,8831)
      &         (ENGDEM(ISTATE,JSIC),JSIC=15,20)
      READ (29,8831)
      &         (ENGDEM(ISTATE,JSIC),JSIC=21,23)
 8831 FORMAT(1X,2X,3X,2X,8(F8.1,1X))
  345 CONTINUE
C
C$$$$ READ ENERGY DEMAND(MWE) & FUEL PRICE(CENTS/KWH) FOR UTILITIES IN
C     EACH STATE.
      READ (9,1009)
      &     (A,UTLDEM(ISTATE,INVUTL),UTLDEM(ISTATE,INVUTL+1),FULPRICE(ISTATE),
      &         ISTATE=1,50)
 1009 FORMAT(V)
C
C$$$$ UPDATE FUEL PRICE TO THE BASELINE YEAR.
      DO 58000 ISTATE=1,50
           FULCPY(ISTATE)=FULPRICE(ISTATE)*UPDATE
58000 CONTINUE
C
```


ORIGINAL PAGE IS
OF POOR QUALITY

```
2430C$$$$ FOR EACH SIC:   SET ENERGY DEMAND ESCALATION & LOAD FACTOR
2440C                     EQUAL TO A CONSTANT INPUT VALUE.
2450C      THESE TWO VARIABLES(ENERGY ESCALATION & LOAD FACTOR)
2460C      ARE SET UP AS ARRAYS IN CASE OF FUTURE PROGRAM MODIFICATION/DATA
2470C      ACQUISITION WHICH WOULD ENABLE INPUT OF DIFFERENT VALUES FOR
2480C      DIFFERENT SICS.
2490C
2500 DO 6700 JSIC=1,NSIC
2510       SICAVG(JSIC)=INDLND
2520       ENGESC(JSIC)=CONSTESC
2530       LOADFC(JSIC)=CONSTLD
2540 6700 CONTINUE
2550C
2560C$$$$ STARTING POINT IF PROGRAM IS RERUN AFTER OUTPUT IS DONE.
2570 899 CONTINUE
2580C
2590C$$$$ PRINT TO THE TERMINAL AN EXAMPLE OF HOW TO INPUT DATA BY
2600C      REDEFINING VARIABLES IN THE NAMELIST DATA GROUP "CHANGE".
2610       PRINT,"INPUT DATA IN THE FOLLOWING FORM."
2620C      PRINT,"$CHANGE VARIABLE1=VALUE1, VARIABLE2=VALUE2,"
2630C      PRINT,"VARIABLE3=VALUE3 $"
2640       PRINT,"EXAMPLE:  $CHANGE SYSCST=1500., STARYR=1992 $"
2650       PRINT," "
2660       PRINT,"IF THERE ARE NO CHANGES, INPUT $CHANGE $"
2670C
2680       READ(4,CHANGE)
2690C
2700C$$$$ PRINT THE NAMELIST "INPUT"( A SUBSET OF "CHANGE") TO THE
2710C      TERMINAL IF REQUESTED BY THE USER.
2720       PRINT,"DO YOU WANT TO SEE THE INPUT? (Y OR N)"
2730       READ,ANSWER
2740       IF (ANSWER .EQ. "Y") WRITE (6,INPUT)
2750C
2760C
2770C$$$$ START MAIN OUTER LOOP ON STATES.
2780 DO 800 ISTATE=1,50
2790C
2800C$$$$ COMPUTE SYSTEM CAPACITY FACTOR BASED ON THE REFERENCE CAPACITY
2810C      FACTOR & THE RATIO OF EACH STATES INSOLATION LEVEL TO THE REFERENCE
2820C      INSOLATION LEVEL.
2830       CAPFAC=REFCAP*(STAINS(ISTATE)/REFINS)
2840C
2850C$$$$ START MAIN INNER LOOP ON SICS.
2860      DO 700 JSIC=1,NSIC
2870C
2880C$$$$ IF THE INDUSTRIAL ENERGY DEMAND FOR A GIVEN STATE & SIC EQUALS 0.,
2890C      THEN SET THE MARKET EQUAL TO 0. & GO TO THE END OF THE INNER LOOP.
2900       IF (ENGDEM(ISTATE,JSIC) .GT. 0. .OR. JSIC .GE. INVUTL) GO TO 80
2910            MKT(ISTATE,JSIC)=0.
2920            GO TO 700
2930C*****GO TO UTILITY SECTION IF JSIC IS OUT OF THE INDUSTRIAL RANGE.
2940       80 IF (JSIC .GE. INVUTL) GO TO 200
2950C
2960C$$$$ START SECTION ON INDUSTRIAL FIRMS.
2970C
2980C$$$$ COMPUTE THE PRICE OF ELECTRICITY IN THE SELECTED START YEAR USING
2990C      THE UPDATED DATA FILE ENERGY PRICES, ELECTRICITY INFLATION RATE
3000C      & START YEAR FROM NAMELIST "CHANGE", AND THE YEAR OF DATA FILE
3010C      PRICES FROM NAMELIST "STAY".
3020C
3030       ELECST=ELECPY(ISTATE,JSIC)*(1.+ELEINF)**(STARYR-ELECYR)
```


ORIGINAL PAGE IS
OF POOR QUALITY

```
3040C
3050C*****LEVELIZE PRICE OF ELECTRICITY OVER PLANNING HORIZON
3060      CALL CR (CAPREC,DISCNT,HORIZN)
3070C
3080      CALL PV(PVESCL,ELEINF,DISCNT,HORIZN)
3090      LEVELC=CAPREC*(PVESCL*ELECST)
3100C
3110C*****LEVELIZE ANNUAL SAVINGS
3120      LEVSAV=(LEVELC/100.)*CAPFAC*8760.
3130C
3140C*****SYSTEM'S RETURN ON INVESTMENT
3150C
3160C$$$$ COMPUTE ROI BASED ON LEVELIZED SAVINGS, TAX RATE(FROM NAMELIST "STAY")
3170C     & SYSTEM COST(FROM NAMELIST "CHANGE").
3180C$$$$ IF THE ROI CALCULATED BEFORE LANDCOST IS CONSIDERED(SYSROI) IS LESS
3190C$$$$ THAN THE MINIMUM REQ'D ROI, SET THE MARKET EQUAL TO ZERO AND
3200C$$$$ GO TO THE NEXT SIC.
3210      SYSROI= (LEVSAV*(1-TAXRAT))/SYSCST
3220      IF(SYSROI .GE. ROIMIN) GO TO 26
3230         MKT(ISTATE,JSIC)=0.
3240         GO TO 700
3250C
3260C
3270C*****LGROUP REFERS TO LAND COST GROUP
3280C*****ASSUMPTION: LAND COSTS IN EACH SIC ARE DISTRIBUTED WITH
3290C*****             THE SAME SHAPE, THOUGH DIFFERENT MEANS, AS
3300C*****             THE LAND COSTS OF THE WHOLE SAMPLE.
3310C$$$$ THIS ASSUMPTION COULD BE CHANGED IF MORE DATA BECOMES AVAILABLE.
3320C
3330C$$$$ START LOOP ON INDUSTRIAL LAND GROUPS TO:
3340C         1. COMPUTE TOTAL SYSTEM COST FOR GIVEN SIC & STATE.
3350C         2. COMPUTE ACTUAL ROI BASED ON SYSTEM COST.
3360C         3. DETERMINE THE FRACTION OF RESPONDENTS FOR WHICH THE SYSTEM
3370C            IS ECONOMIC.
3380 26  DO 150 LGROUP = 1,NGROUP
3390        FREQ(LGROUP)=0.
3400        LANDCT=LCSIND(LGROUP)*(SICAVG(JSIC)/INDLND)
3410C
3420C$$$$      COMPUTE SYSTEM COST.
3430        TOTCST=SYSCST+(REQLND*LANDCT)*
3440     &     ((1.+LNDINF)**(STARYR-LANDYR))
3450C
3460C*****     CALCULATE ACTUAL RETURN ON INVESTMENT
3470C
3480        ACTROI=(LEVSAV*(1.-TAXRAT))/TOTCST
3490C
3500C*****     CHECK TO SEE IF ACTUAL ROI IS GREATER THAN REQUIRED ROI
3510C
3520C*****     IROI REFERS TO ROI GROUP
3530C
3540              DO 140 IROI=1,NROI
3550                IF(ROI(1) .GT. ACTROI) GO TO 155
3560                IF (ROI(IROI) .GT. ACTROI) GO TO 150
3570                   FREQ(LGROUP) = CUMFRI(IROI)
3580              140 CONTINUE
3590       150 CONTINUE
3600C
3610C$$$$ AFTER NORMAL COMPLETION OF THE DO 150 LOOP, BYPASS THE DO 1555 LOOP.
3620C     THE DO 1555 LOOP ZEROES FREQ(LGROUPS) FOR WHICH THE INVESTMENT IS
3630C     NOT ECONOMIC.
3640      GO TO 160
```

ORIGINAL PAGE IS
OF POOR QUALITY

ISSEC 100001 REV. 10-01-79

```
      DO 1555 I=LGROUP,NGROUP
         FREQ(I)=0.
1555  CONTINUE
C$$$$ DETERMINE THE FRACTION (PCTECN) OF ALL LAND COST GROUPS FOR WHICH THE
C     SYSTEM IS ECONOMIC BASED ON THE FRACTION OF RESPONDENTS IN EACH
C     COST GROUP & THE FRACTION OF THESE RESPONDENTS FOR WHICH THE SYSTEM
C     IS ECONOMIC.
      160 PCTECN=0.
      DO 167 LGROUP=1,NGROUP
           PCTECN =PCTECN + FREQ(LGROUP)*FRLNDI(LGROUP)
      167 CONTINUE
C$$$$ IF THE FRACTION FOR WHICH THE SYSTEM IS ECONOMIC IS ZERO, THEN
C     SET THE MARKET EQUAL TO ZERO & DO THE NEXT SIC.
      IF (PCTECN .GT. 0.) GO TO 170
           MKT(ISTATE,JSIC)=0.
           GO TO 700
C
      170 CONTINUE
C*****CALCULATE THE YEAR THE SYSTEM BECOMES ECONOMIC
C
      REQELC=(ROIMIN*SYSCST*100.)/((1.-TAXRAT)*
     &            (CAPFAC*8760.))/(CAPREC*PVESCL)
      YEARSN=ALOG(REQELC/ELECPY(ISTATE,JSIC))/ALOG(1.+ELEINF)
      ECONYR=ELECYR+INT(YEARSN)+1
       IF (ECONYR .LT. 1980) ECONYR=1980
      HOWLNG(ISTATE,JSIC) = STARYR - ECONYR
C
C$$$$ COMPUTE SECTOR DEMAND IN THE BASE YEAR & START YEAR.
      SDBY = ENGDEM(ISTATE,JSIC)*1000./(8760*LOADFC(JSIC))
      SDSY= SDBY * ((1 + ENGESC(JSIC))**(STARYR-CONSYR))
      GO TO 699
C
C$$$$ START SECTION ON UTILITIES.
C
C$$$$ IF THE ENERGY DEMAND FOR THE GIVEN SECTOR & STATE EQUALS ZERO, THEN
C     SET THE MARKET EQUAL TO ZERO & DO THE NEXT SIC.
200   IF(UTLDEM(ISTATE,JSIC) .GT. 0.)GO TO 44444
         MKT(ISTATE,JSIC)=0.
         GO TO 700
C$$$$ UPDATE FUEL COST TO THE START YEAR.
44444 ESCFUL = (1+GINF)*(1+FULINF) -1
      FULSTA = FULCPY(ISTATE) * (1+ESCFUL)**(STARYR-FUELYR)
C$$$$ DEFINE ELECST AS FULSTA WITHOUT INFLATION.
C     ELECST IS USED IN THE OUTPUT SECTION.
      ELECST = FULCPY(ISTATE) * (1+FULINF)**(STARYR-FUELYR)
C$$$$ LEVELIZE FUEL COST TO START YEAR.
      CALL CR (CAPREC,DISCUT,HZNUTL)
      CALL PV(PVESCL,ESCFUL,DISCUT,HZNUTL)
      LEVELC = CAPREC * PVESCL * FULSTA
C$$$$ LEVELIZE ANNUAL SAVINGS.
      LEVSAV = (LEVELC/100) *CAPFAC *8760
C$$$$ COMPUTE THE ACTUAL FCR.
      SYSFCR = LEVSAV/(SYSCST*(1+GINF)**(STARYR-PRICYR))
C$$$$ IF THE ACTUAL FCR IS LESS THAN THE MINIMUM REQUIRED, SET THE MARKET
C     EQUAL TO ZERO AND DO THE NEXT SIC.  THE REQUIREMENT FOR NON-INVESTOR
C     UTILITIES IS THE FCR TIMES ORATIO DUE TO EXEMPTION FROM FEDERAL
C     CORPORATE TAXES.
      IF((JSIC .EQ. INVUTL) .AND. (SYSFCR .GE. FCRMIN)) GO TO 260
      IF((JSIC .GT  INVUTL) .AND. (SYSFCR .GE. ORATIO*FCRMIN)) GO TO 260
      MKT(ISTATE,JSIC)=0.
      GO TO 700
```

ORIGINAL PAGE IS
OF POOR QUALITY

ACC LOGOS1 REV 1 10-01-79

```
4260C
4270C*****LGROUP REFERS TO LAND COST GROUP.
4280C*****ASSUMPTION: LAND COSTS IN EACH TYPE OF UTILITY
4290C*****            ARE DISTRIBUTED WITH THE SAME SHAPE AND MEAN.
4300C$$$$ START LOOP ON UTIILITY LAND COST GROUPS TO :
4310C         1. COMPUTE TOTAL SYSTEM COST FOR GIVEN SIC & STATE.
4320C         2. COMPUTE ACTUAL FCR BASED ON SYSTEM COST.
4330C         3. DETERMINE THE FRACTION OF RESPONDENTS FOR WHICH THE SYSTEM
4340C            IS ECONOMIC.
4350C
4360       260 DO 1500 LGROUP = 1,MGROUP
4370             FREQ(LGROUP)=0.
4380             LANDCT=LCSUTL(LGROUP)
4390C
4400C*****
4410C*****YEARSN IS THE NUMBER OF YEARS TIL THE SYSTEM BECOMES
4420C*****ECONOMIC FOR ANY OF THIS SIC.
4430C*****
4440             TOTCST=(SYSCST+((REQLND*LANDCT))*
4450          &        ((1.+LNDINF)**(STARYR-LANDYR)))
4460             & *((1.+GINF)**(STARYR-PRICYR))
4470             ACTFCR = LEVSAV/TOTCST
4480C
4490                  DO 1400 IFCR=1,NFCR
4500                IF(((JSIC .EQ. INVUTL) .AND. (FCR(1) .GT. ACTFCR))
4510 &                .OR. ((JSIC .GT. INVUTL) .AND. (ORATIO*FCR(1) .GT. ACTFCR)))
4520 &                GO TO 1550
4530                  IF ((JSIC .EQ. INVUTL) .AND. (FCR(IFCR) .GT. ACTFCR))
4540 &                    GO TO 1500
4550                  IF ((JSIC .GT. INVUTL) .AND.
4560                  &   (ORATIO*FCR(IFCR) .GT. ACTFCR))
4570 &                    GO TO 1500
4580C
4590                       FREQ(LGROUP) = CUMFRU(IFCR)
4600                  1400 CONTINUE
4610       1500 CONTINUE
4620C$$$$ AFTER NORMAL COMPLETION OF THE DO 1500 LOOP, BYPASS THE DO 15550 LOOP.
4630C      THE DO 1555 LOOP ZEROES FREQ(LGROUPS) FOR WHICH THE INVESTMENT IS
4640C      NOT ECONOMIC.
4650       GO TO 1600
4660 1550   DO 15550 I=LGROUP,MGROUP
4670           FREQ(I)=0.
4680 15550 CONTINUE
4690C
4700C$$$$ DETERMINE THE FRACTION (PCTECN) OF ALL LAND COST GROUPS FOR WHICH THE
4710C      SYSTEM IS ECONOMIC BASED ON THE FRACTION OF RESPONDENTS IN EACH
4720C      COST GROUP & THE FRACTION OF THESE RESPONDENTS FOR WHICH THE SYSTEM
4730C      IS ECONOMIC.
4740       1600  PCTECN=0.
4750       DO 1670 LGROUP=1,MGROUP
4760            PCTECN =PCTECN + FREQ(LGROUP)*FRLNDU(LGROUP)
4770       1670 CONTINUE
4780C
4790C$$$$ IF THE FRACTION FOR WHICH THE SYSTEM IS ECONOMIC IS ZERO, THEN
4800C      SET THE MARKET EQUAL TO ZERO & DO THE NEXT SIC.
4810       IF (PCTECN .GT. 0.) GO TO 1700
4820            MKT(ISTATE,JSIC)=0.
4830            GO TO 700
4840       1700 CONTINUE
4850C
4860C$$$$ COMPUTE REQUIRED FUEL COST FOR THE SYSTEM TO BE ECONOMIC
```


ORIGINAL PAGE IS OF POOR QUALITY

```
      IF (JSIC .EQ. INVUTL)
     &     REQFUL =(FCRMIN*SYSCST*100.)/((CAPFAC*8760)*(CAPREC*PVESCL))
      IF (JSIC .GT. INVUTL)
     &     REQFUL =(ORATIO*FCRMIN*SYSCST*100.)/((CAPFAC*8760)*
     &            (CAPREC*PVESCL))
C*****
C*****YEARSN IS THE NUMBER OF YEARS TIL THE SYSTEM BECOMES
C*****ECONOMIC FOR ANY OF THIS UTILITY TYPE.
C*****
      YEARSN=ALOG(REQFUL/FULCPY(ISTATE))/ALOG(1.+FULINF)
      ECONYR=FUELYR+INT(YEARSN)+1
       IF (ECONYR .LT. 1980) ECONYR=1980
      HOWLNG(ISTATE,JSIC) = STARYR - ECONYR
C
      SDBY = UTLDEM(ISTATE,JSIC)
      SDSY= SDBY * ((1 + ENGESC(JSIC))**(STARYR-CAPYR))
C
699 CONTINUE
C$$$$ USING THE DILUTION FACTOR, COMPUTE SYSTEM DEMAND.
      SDMAX(ISTATE,JSIC) = SDSY * DF(JSIC)
C
C$$$$ COMPUTE THE MARKET (IN MEGAWATTS).
      IF(JSIC .LT. INVUTL)MKT(ISTATE,JSIC)=PCTECN*SDMAX(ISTATE,JSIC)*INDMAX
     &                    *PENETR(HOWLNG(ISTATE,JSIC),HALFPN,SHAPE)
      IF(JSIC .GE. INVUTL)MKT(ISTATE,JSIC)=PCTECN*SDMAX(ISTATE,JSIC)*UTLMAX
     &                    *PENETR(HOWLNG(ISTATE,JSIC),HALFPN,SHAPE)
      IF(FIRST)WRITE(6,33333)
33333 FORMAT(//"MARKET BREAKDOWN BY STATE & SIC")
     IF(FIRST)PRINT," "
    IF(FIRST)PRINT,"ST. SIC   MKT.(MWE)   % PENTR.   ELEC. PRICE(CTS./KWH)"
      FIRST=.FALSE.
C$$$$ DEFINE % PENETRATION & INCLUDE IN PRINTOUT.
      PCTPEN=100.*MKT(ISTATE,JSIC)/SDSY
C$$$$ IF THE MARKET IS GREATER THAN ZERO, PRINTOUT: STATE ABBREVIATION,
C     SIC, MARKET, PERCENT OF PENETRATION, & ELECTRICITY PRICE.
      IF (MKT(ISTATE,JSIC) .GT. 0.) WRITE(6,56)
     &      STABRV(ISTATE),ACTSIC(JSIC),MKT(ISTATE,JSIC),PCTPEN,ELECST
      56 FORMAT (1X,A2,2X,I2,E12.3,2X,F8.4,3X,F8.4)
700 CONTINUE
800 CONTINUE
C$$$$ END OF MAIN LOOPS
C
C$$$$ PROVIDE OUTPUT OF MARKET BREAKDOWN BY SIC.
      WRITE(6,4444)
4444 FORMAT(" ",/"BREAKDOWN OF TOTAL MARKET(FOR ALL STATES) BY SICS"//,
     &            12X,"SIC",7X,"MKT(MWE)"/)
      DO 4848 JSIC=1,NSIC
         MKTSIC(JSIC)=0.
         DO 5858 ISTATE=1,50
            MKTSIC(JSIC)=MKTSIC(JSIC)+MKT(ISTATE,JSIC)
         5858 CONTINUE
            IF(MKTSIC(JSIC) .GT. 0.) WRITE(6,6868)ACTSIC(JSIC),MKTSIC(JSIC)
6868        FORMAT(" ",10X,I3,5X,E12.3)
      4848 CONTINUE
C
C$$$$ COMPUTE & PRINTOUT THE TOTAL MARKET FOR ALL SICS & STATES.
SDSUM=0.
MKTSUM=0.
DO 2800 ISTATE=1,50
      DO 2700 JSIC=1,NSIC
         SDSUM=SDSUM + SDMAX(ISTATE,JSIC)
```

ORIGINAL PAGE IS
OF POOR QUALITY

```
5480            MKTSUM=MKTSUM+MKT(ISTATE,JSIC)
5490       2700 CONTINUE
5500  2800 CONTINUE
5510  PRINT," "
5520  PRINT,MKTSUM,"= THE TOTAL MARKET (FOR ALL SICS & ALL STATES)"
5530  SDMAVG=SDSUM/(50*NSIC)
5540C
5550C$$$$ GIVE USER OPTION TO RERUN PROGRAM(WITHOUT RECOMPILING).
5560       PRINT,"AGAIN? (Y OR N)"
5570       READ,ANSWER
5580       IF (ANSWER .EQ. "Y") GO TO 899
5590C
5600C$$$$ GIVE USER OPTION TO SAVE MOST RECENT DATA PUT INTO NAMELIST "CHANGE".
5610  PRINT,"DO YOU WANT TO RESAVE THE MOST RECENT $CHANGE DATA? (Y OR N)"
5620  READ,ANSWER
5630  IF (ANSWER .NE. "Y") STOP
5640       REWIND 43
5650       WRITE (43,CHANGE)
5660  STOP
5670  END
5680C$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
5690C$$$$ SUBROUTINE CR COMPUTES THE CAPITOL RECOVERY FACTOR.
5700  SUBROUTINE CR(CAPREC,DISCNT,HORIZN)
5710       CAPREC=((1.+DISCNT)**HORIZN*DISCNT)/
5720   &          ((1.+DISCNT)**HORIZN-1.)
5730  RETURN
5740  END
5750C$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
5760C$$$$ SUBROUTINE PV COMPUTES PRESENT VALUE.
5770  SUBROUTINE PV(PVESCL,ELEINF,DISCNT,HORIZN)
5780       IF (ABS((ELEINF - DISCNT)/DISCNT) .LT. .001) GO TO 100
5790            PVESCL=((1.+ELEINF)/(DISCNT-ELEINF))*
5800   &                    (1.-((1.+ELEINF)/(1.+DISCNT))**HORIZN)
5810            GO TO 120
5820       100 PVESCL=HORIZN
5830  120 RETURN
5840  END
5850C$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
5860C$$$$ FUNCTION PENETR COMPUTES THE MARKET PENETRATION.
5870  FUNCTION PENETR(YEARS,HALFPN,SHAPE)
5880  INTEGER YEARS,HALFPN
5890                 AA=-SHAPE * HALFPN
5900                 XX=AA + SHAPE*YEARS
5910                 YY=EXP(XX)
5920C
5930                 PENETR = YY/(YY+1)
5940  RETURN
5950  END
```


ORIGINAL PAGE IS
OF POOR QUALITY

APPENDIX D

BIBLIOGRAPHY

BIBLIOGRAPHY

1. "Ocean Thermal Energy Conversion Mission Analysis Study, Phase I, Volume I Final Report", General Electric Company Tempo, June 1977.

2. "Commercial Applications of Solar Total Energy Systems", Rockwell International, Atomics International Division, July 1976.

3. "Market Overview For Small Power Systems Applications", Jet Propulsion Laboratory, September 1978, R. Gurfield & C. Davis.

4. "Commercialization of Small Solar Thermal Electric Power Systems: Alternatives for Accelerating Their Adoption", Jet Propulsion Laboratory, T.J. Kuehn, D.L.P. Strange, P.M. Nawrocki.

5. "An Overview Of Power Plant Options For The First Small Power System Experiment: Engineering Experiment No. 1", November 9, 1978, Philip Walden.

6. "Project cost goals For Small Power Systems Utility Applications - Preliminary Report", Jet Propulsion Laboratory, R. Gurfield & C. Davis.

7. "An Overview Of The Potential Economic Viability Of Small Solar Thermal Dispersed Power Plants In Small Generating Utilities", Jet Propulsion Laboratory, November 1978, Steven A. Bluhm.

8. "Solar Thermal Power Plants into Electric Utility Systems", Southern California Edison Company, Volumn 1, September 1976.

9. "Trip Reports on visits to Utilities in the Southwest to Ascertain Cost goals for Small Power systems", Jet Propulsion Laboratory, March 16, 1978, R. Gurfield.

10. "Executive Summary Point Focusing Distributed Receiver Technology Project", Jet Propulsion Laboratory, Fiscal Year 1978.

11. "Thermal Dispersed Power Program total Energy Systems Project", The Aerospace Corporation, December 1, 1978.

12. "Systems Descriptions and Engineering Costs for Solar-Related Technologies, Volume 1, Summary", The MITRE Corporation", June 1977.

13. "Advanced Military Power System", A Technology Concept Demonstration Paper, July 18, 1978, Thomas J. Kuehn.

14. "The Market Dynamics of Technological Substitutions", American Elsevier Publishing Company, Inc., 1974, A. Wade Blackman, Jr.

15. "Industrial/Utility Co-Location for Process Steam and Power", Thermal Power systems Engineering, Industrial Sales Division, General Electric Co., John M. Kovacik.

16. "The Role of Turbines in Industrial Energy Systems", Industrial Turbine Seminar, October 16-17, 1968, W.B. Wilson, General Electric Co.

17. "Turbine Systems to Reduce Petroleum Refining and Petrochemical Plant Energy Costs", American Society of Mechanical Engineers, W.B. Wilson & J.M. Kovacik, General Electric Co.

18. "Solar Energy and Electric Utilities: Can They Be Interfaced?", Argonne National Laboratory, August 1976, Joseph G. Asbury & Ronald O. Mueller.

19. "Solar Energy: A View From An Electric Utility Standpoint", Electric Power Research Institute, April 21-23, 1975, Dwain F. Spencer.

20. "Small Power systems Mission Analysis Management Overview", October 3, 1978.

21. "Midtemperature Soalr Systems Test Facility (MSSTF) Project Test Results: Phase IVA MSSTF System Operation", Sandia Laboratories, November 1978, Thomas D. Harrison & William H. McCulloch.

22. "The National Energy Act", DOE.

23. "Potential Industry Market for Gas Fired Heat Pump", July, 1975, J.P. Foley, General Electric Co.

24. "Support to ORNL in Solar Total Energy Systems (STES) Mission Analysis", The Aerospace Corporation, October 4, 1978.

25. "Solar Thermal Dispersed Power Program Total Energy systems Project", The Aerospace Corporation, December 1, 1977.

26. "State Solar Energy Legislation of 1976: A Review of Statutes Relating to Buildings", National Bureau of Standards, September 1977.

27. "A Survey of State Legislation Relating to Solar Energy", National Bureau of Standards, April 1976.

28. "Public Utility and Solar Energy Interface: An Assessment of Policy Options", Energy Research and Development Administration, December 31, 1976, S.L. Feldman & B. Anderson.

29. "Analysis of Policy Options for Accelerating Commercialization of Solar Heating and Cooling Systems", The George Washington University, May 27, 1977, Roger Bezdek, Joseph Margolin, Thomas Sparrow, George Sponsler, Arthur Ezra, Robert Spongberg, Allan Miller, Fred Meeker, Elliot Roseman, Marion Misch.

30. "Solar Energy Research and Development Program Balance, A Review by the Solar Working Group", U.S. Department of Energy, February 1978.

31. "Parallel Operation of Customer Generation", Georgia Power, January 15, 1979, E.J. Ney.

32. "Guidelines for a Small Solar Thermal Power System Commercialization Strategy", Resource Planning Associates, Inc., December 28, 1979, Jack Stafurik.

33. "An Overview of Power Plant Options for the First Small Power System Experiment: Engineering Experiment Number 1", Jet Propulsion Laboratory.

34. "Market Overview Study For Small Solar Thermal Power Systems", Jet Propulsion Laboratory, January 1979, R. Gurfield & C. Davis.

35. "Application of Solar Technology to Today's Energy Needs", Office of Technology Assessment.

36. "Solar Energy", U.S. Department of commerce, 1977.

37. "Utilities Put the Sun to Work", Pri Journal, March 1978.

38. "Solar Thermal Electric Power Systems, Volume 3, Appendices", National Technocal Information Service, November 1974.

39. "Proceedings of Small Power Systems Solar Electric Workshop, Volume II: Invited Papers", U.S. Department of commerce, February 1978.

40. "Solar Thermal Electric Power Systems, Volume 1, Executive Summary", National Technical Information Service, November 1974.

41. "Siting Issues for Solar Thermal Power Plants With Small Community Applications", Jet Propulsion Laboratory, July 20, 1978, H.J. Holback & S.J. Ireland.

42. "Energy Conservation with Fired Heaters", EG & G. Idaho, Inc., December 1978, Neil D. Cox.

43. "Thermal Electric Power", Astronautics & Aeronautics.

44. "Storage Systems for Solar Thermal Power", August 20-25, 1978.

45. "The Value of Energy Storage for direct-Replacement Solar Thermal Power Plants", Soalr Energy Research Institute, February 14-15, 1978, Truman D. Anderson, et al.

46. "commercial Applications of Solar Total Energy systems", Energy Research and Development Administration Division of Solar Energy, September 1977.

47. "Development of A 1 KW, Organic Rankine Cycle Power Plant for Remote Applications", Sundstrand Energy Systems, John Monahan & Ron McKenna.

48. "Solar Thermal Dispersed Power Program, Total Energy Systems Project", The Aerospace corporation, March 31, 1979.

49. "Solar Thermal Dispersed Power Program, Total Energy Systems Project", Sherman H. Clark Associates, March 31. 1978.

50. "Advanced Energy Programs Small Dispersed Solar Electric Total Energy Systems", General Electric Co.

51. "Solar Thermal Electric Power Systems, Volume 2, Systems Studies and Economic Evalautions", National Technical Information Service, November 1974.

52. "Additions to Generating Capacity 1978-1987 for the Contiguous United States", U.S. Department of Energy, October 1978.

53. "Solar Energy A Comparative Anaysis to the Yeat 2020", The MITRE Corporation.

54. "An Alternative, Semi-Automated Method for Performing Multi-objective Analyses", Brookhaven National Laboratory, August 1978, J. Schank.

55. "Thermal Power Systems Small Power Systems Applications Project", Jet Propulsion Laboratory, January 11, 1979.

56. "Decision Analysis for Evalauting and Ranking Small Solar Thermal Power System Technologies, Volume II - The Criteria and Methodology for Evaluation and Ranking", Jet Propulsion Laboratory, January 15, 1979.

57. "Decision Analysis for Evaluating and Ranking Small Solar Thermal Power System Technologies, Volume I - A Brief Introduction to MDA Electric Power system Production Costing and Reliability Including Hydro-Electric, Storage, and Time Dependent Power Plants", January 1979, Susan Finger.

58. "Integration of Solar Thermal Power Plants into Electric Utility Systems, Southern California Edison Company, Volume 1", September 1976.

59. "JPL Reference Scenario on Energy Prices", Jet Propulsion Laboratory, September 15, 1978, K.L. Terasawa & K.R. Ugone.

60. "Solar Thermal Dispersed Power Program total Energy Systems Project, Final Technical Summary Report, Volume 1: Solar Total Energy Systems Market Penetration", The Aerospace Corporation, March 31, 1978.

61. "Solar Thermal Dispersed Power Program total Energy Systems Project, Final Technical Summary Report, Volume II: Energy Use and Price Forecasts, Sherman H. Clark Associates, March 31, 1978.

62. "The Cost of Energy From Utility - Owned Solar Electric Systems", Energy Research & Development Administraiton, June 1976.

63. "Small Power Systems Study, Quarterly Report No. 1", Solar Energy Research Institute, July 1, 1978, John P. Thornton, et al.

64. "Development of a Small Power Systems Financial Analysis Computer Program The SPSFA Program" ESC Energy Corporation.

65. "Financial Anaysis of Solar Thermal Power Plants".

66. "Point Focusing Distributed Receiver Technology Project", Jet Propulsion Laboratory, Fiscal Year 1978.

67. "Thermal Power systems Small Power Systems Applications Project Annual Technical Report, Volume 1 - Executive Summary", Fiscal Year 1978.

68. "Thermal Power Systems Small Power Systems applications Project, Decision Analysis for Evaluating and Ranking Small Solar Thermal Power System Technologies, Volume II - The Criteria And Methodology for Evaluation and Ranking", Jet Propulsion Laboratory, January 15, 1979.

69. "Utility Alternatives for Solar Energy", Public Utilities Fortnightly, January 5, 1978, John K. Freeman.

70. "Social Costs for Alternate Means of Electrical Power Generation for 1980 and 1990, Reference Report, Chapter I. Introduction", Argonne National Laboratory.

71. "In-Plant Generation-Design Considerations for Industrial Facilities", Transactions on Industry Applications, Vol. IA-12, No. 3, May/June 1976, Sidney Stoller.

72. "Putting the Sun to Work in Industry", February 28, 1979.

73. "Energy Price and Consumption Forecasts: Overview of the DRI Energy Mo and Its Application, Keith R. Ugone.

74. "Section II Solar Thermal Technology", Phil Walden.

75. "Solar Thermal Conversion Mission Analysis, Volume II: Demand Analysis National Technical Information Service, January 1974.

76. "Cogeneration: What it Means to Plant Engineers", Plant Engineering, August 3, 1978, Ed Palko.

77. "International Energy Conservation: comparative Law and Policy, Proceedings from the 1978 International Conference on Energy Conservation", U.S. Department of Energy, February 1979.

78. "SPSA Applications Study Energy for California Water Systems", March 23, 19, C. Davis & R. Gurfield.

79. "Utility Investment in On-Site Solar: risk and Return Analysis for Capitalization and Financing", Lawrence Berkeley Laboratory, September 1978, Edward Kahn & Stephen Schultz.

80. "Barriers and Incentives to Small Solar Thermal Power Systems: Working Paper Resource Planning Associates Inc., September 19, 1978.

81. "Interim Report on Small Power Systems Study", Energy Systems Group, January 15, 1978.

82. "Small Power Systems DOD Applications".

83. "Dispersed Power Systems Quarterly Review Small Power Systems Management Overview", June 27, 1978.

84. "Solar Thermal Repowering, The MITRE Corporation.

85. "Market Evalaution Summary Solar Hybrid Repowering, Public Service co. of New Mexico, J.D. Maddox.

86. "The Potential for cogeneration Development in Six Major Industries by 1985", Resource Planning Associates, Inc., December 1977.

87. "Phase I of the First Small Power System Experiment (Experimental System No. 1), Jet Propulsion Laboratory, July 3, 1979.

88. "Project Cost Goals for Small Power Systems Utility Applications - Preliminary Report", Jet Propulsion Laboratory. September 1978, Robert N. Gurfield & Calvin Davis.

89. "Thermal Power Systems Advanced Solar Thermal Technology Project Techno-Economic Projections for Advanced Dispersed SolarThermal Electric Power Plants to Years 1990-2000", Jet Propulsion Laboratory, November 1978, T. Fujita, et al.

90. "Solar Thermal Dispersed Power Program Small Power Systems Study, Technical Summary Report, Volume I: Study Results", The Aerospace Corporation, May 31, 1978.

91. "Solar Thermal Dispersed Power Systems Small Power Systems Study, Technical Summary Report, Volume II: Inventory of Small Generating Units in U.S. Utility Systems", The Aerospace corporation, May 31, 1978.

92. "Economic Evaluation of Industrial Turbine-Generators", Thermal Power Systems Engineering, Industrial Sales Division, Martin C. doherty.

93. "Ocean Thermal Energy Conversion Mission Analysis Study, Phase I, Volume II, Appendices to Final Report, General Electric Company - Tempo, June 1977.

94. "Cogeneration Technology Alternatives Study -CTAS-, Volume III - Energy Conversion System Recommendations", General Electric, Energy Systems & Technology division, April 18, 1978.

95. "Cogeneration Technology Alternatives Study -CTAS- Initial Oral Briefing, Volume II - Technical approach", General Electric, Energy Systems & Technology division, April 18, 1978.

96. "Cogeneration Technology Alternatives Study, Volume I - Detailed Study Approach", General Electric Company, Energy Systems and Technology Division, April 17, 1978.

97. "Technical and Financial Factors Involved in the Generation and Use of Steam in Industry", RPA.

98. "Briefing on U.S. Industrial Cogeneration Market", Resource Planning Associates, Inc., September 21, 1978, Peter G. bos, James Williams.

99. "Energy Projections and Narrative Wind Energy Mission Analysis - task 1", General Electric - Tempo, August 5, 1975.

100. "OTEC Mission Analysis Study, Ammonia and Aluminum Options", General Electric, Tempo.

101. "Energy Storage Systems Program Overview", Department of Energy, Fiscal Year 1978.

102. "Institutional Applications of Solar Total-Energy systems Draft Final Report - Volume 1", Resource Planning Associates, Inc., July 1978.

103. "Institutional Applications of Solar Total-Energy Systems Draft Final Report - Volume 2 (Appendixes)", Resource Planning Associates, Inc., July 1978.

104. "Results of Comprehensive Literature Survey for the Regional Insolation Effects Study", Jet Propulsion Laboratory, September 14, 1978, T. Fujita.

105. "Preliminary Economic Analysis of Solar Irrigation Systems (SIS) for Selected Locations", Sandia Laboratories, November 1977, Laurance L. Lukens, et al.

106. "Utility Investment In On-Site Solar: Risk and Return Analysis for Capitalization and Financing", Lawrence Berkeley Laboratory, September 1978.

107. "Distributed Solar Power Systems: An Option", Summer 1978, Aden B. Meinel & Marjorie P. Meinel.

108. "The Industrialization of Small Solar Thermal Power Systems", Jet Propulsion Laboraotry, D.L.P. Strange, P.C. Walden & T.J. Kuehn.